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QUATERNARY LITHOSTRATIGRAPHY OF THE MARTINSVILLE AREA NORTH TO THE MARTINSVILLE ALTERNATIVE SITE

B. Brandon Curry, Richard C. Berg, and, Madalene R. T. Cartwright

an open file report to Battelle Memorial Institute

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Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

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ILLINOIS STATE GEOLOGICAL SURVEY
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CONTENTS

Figures

Tables

INTRODUCTION

The study for a potential site for a low-level radioactive waste disposal facility near Martinsville, Illinois, includes evaluation of the extent and continuity of permeable units between the Martinsville Alternative Site (MAS) and Martinsville water supply wells. This report describes the lithology, thickness and distribution of Quaternary stratigraphic units in the vicinity of the Martinsville water-well field, and correlates the units with those described at the MAS by Curry et al. (1991; fig. 1). Interpretations are based on the study of borings obtained from eight localities south of the MAS, including 157 particle-size determinations and other measurements, such as moisture content and semi-quantitative mineralogy of the less than 2 µm fraction (Battelle Memorial Institute and Hanson Engineers, Inc., 1990c). On the basis of these data, this report refines or in some cases, modifies conclusions or interpretations of the genesis of some deposits discussed in an earlier Illinois State Geological Survey report on the Quaternary geology of the MAS (Curry et al., 1991). Many figures in the report include interpretations of data from the MAS and supercede figures in Curry et al. (1991). In addition, interpretations of lithostratigraphic units based on visual descriptions and laboratory data on subsamples are listed in the appendix. Chapter 7 of Battelle Memorial Institute and Hanson Engineers, Inc. (1990b,c) utilizes the same data as this report.

We obtained information in the area south of the MAS to determine:

1. The lithostratigraphic framework associated with aquifers that supply water to the city of Martinsville;
2. The nature of the continuity of lithostratigraphic units between the MAS and Martinsville, and interconnections between different hydraulically conductive units.

As in previous studies of the MAS (Curry et al., 1991; Battelle Memorial Institute and Hanson Engineers, Inc. 1990a,b), interpretations regarding the continuity of sand and gravel units are evaluated by integrating the lithostratigraphic framework with potentiometric head data, groundwater geochemistry data, and aquifer-test data, where available.

FINDINGS

1. Aquifers supplying water to the city of Martinsville include the sand and gravel facies of the Mulberry Grove Member of the Glasford Formation and Cahokia Alluvium. The city of Martinsville does not use the Martinsville sand as an aquifer (Battelle Memorial Institute and Hanson Engineers, Inc., 1990b).

2. The Mulberry Grove Member above two significant buried bedrock valleys is continuous between the MAS and the city of Martinsville. The sand and gravel facies is thickest (as much as 34 feet) along the North Fork Embarras buried bedrock valley, which generally underlies the present-day North Fork Embarras River valley. The sand and gravel facies of the Mulberry Grove Member above the Martinsville buried bedrock valley south of the MAS is less than about 15 feet thick.

3. The Mulberry Grove Member beneath the present-day valley of the North Fork Embarras River generally is overlain by less than 10 feet of compact diamicton of the Vandalia Till Member. This sequence underlies about 30 to 35 feet of Cahokia Alluvium.

4. The network of buried bedrock valleys that cut into Pennsylvanian bedrock appear to be a deranged drainage system, possibly resulting from superposition and piracy of valley segments during Pre-Illinoian glaciation. The Martinsville sand is the lowest potential aquifer in the glacial drift sequence, and was deposited in the deepest bedrock valleys.

5. Petersburg Silt is very thin (less than 1 foot thick) south of the MAS.

6. The lithology of diamicton in the Smithboro Till Member of the Glasford Formation is different in the two buried bedrock valleys south of the MAS; the silt loam diamicton facies occurs in the North Fork Embarras bedrock valley, whereas the loam diamicton facies occurs in the Martinsville bedrock valley.

7. The lithology of diamicton in the Vandalia Till Member of the Glasford Formation is more poorly sorted south of the MAS than in the Vandalia at the MAS. In addition, the Vandalia contains inclusions of weathered colluvium and bedrock that were not observed in cores during earlier investigations of the MAS.

TECHNICAL PROCEDURES

Continuous cores of glacial drift and unconsolidated alluvium were obtained from eight localities by using the technical procedures outlined by Hanson Engineers, Inc. (1989a,b). These localities, south of the MAS to within or near the city of Martinsville, are labeled alphanumerically A-1 to H-1 in figure 1. The labels correspond to the notations of Battelle Memorial Institute and Hanson Engineers, Inc. (1990b). At least 10 feet of bedrock was sampled at each location, and split-spoon samples were retrieved adjacent to primary borings at several locations to resample zones with significant core loss. Natural gamma (geophysical) logs and driller's notes indicate that core loss generally occurred in materials predominantly composed of sand and gravel or intercalated beds of diamicton and sorted granular sediment (Battelle Memorial Institute and Hanson Engineers, Inc., 1990b).

Table 1 lists basic statistics (i.e., number, mean, standard deviation, and range) on core subsamples of the lithostratigraphic units. Data selected from the project database (Battelle Memorial Institute and Hanson Engineers, Inc., 1990c) for statistical analysis include particle-size distribution, coefficient of uniformity, moisture content, and Atterberg Limits. Hanson Engineers, Inc. (1989 a,b) describes the technical procedures used to obtain these data. The Illinois State Geological Survey conducted the semiquantitative mineralogical analyses following the procedures in ISGS (1990), also summarized in Table 1 and in the project database (Battelle Memorial Institute and Hanson Engineers, Inc., 1990c).

BEDROCK LITHOSTRATIGRAPHY

The upper bedrock south of the MAS consists of shale, siltstone, claystone, sandstone and limestone of the Pennsylvanian Modesto and Bond Formations. In most cases, the rock in the cores is weak to very weak and contains discontinuities in the uppermost 3 feet, especially along bedding planes. The material lacks clay minerals or structures typical of weathering profiles, which indicates the weak character is diagenetic.

BEDROCK TOPOGRAPHY, DRIFT THICKNESS, AND QUATERNARY LITHOSTRATIGRAPHY

Introduction

Data from cores A-1 to H-1 modify or substantiate previous descriptions and genetic interpretations of the bedrock topography and lithostratigraphic units (Battelle Memorial Institute and Hanson Engineers, Inc., 1990b; Curry et al., 1991). Lithostratigraphic units between Martinsville and the MAS are correlated by their stratigraphic position, lithological and pedological core descriptions, and confirmatory laboratory data such as particle-size distribution, sorting (coefficient of uniformity), moisture content, and semi-quantitative mineralogy. Table 2 (Curry et al., 1991) correlates the stratigraphic units designated in this report with those used by Battelle Memorial Institute and Hanson Engineers, Inc. (1990a,b). Figure 2 provides a summary description of the lithostratigraphic units. Isopach maps for the most significant lithostratigraphic units have been updated. Figures 3 to 9 are cross sections that show interpretations of correlation and continuity of lithostratigraphic units and related lithofacies.

Bedrock Topography

Data from cores A-1 to H-1 both confirm and modify previous interpretations of the buried bedrock topography (fig. 10). The North Fork Embarras bedrock valley continues south of the MAS, generally parallel and nearly coincident with the modern valley of the North Fork Embarras River

as mapped by Horberg (1950). The southward gradient of the buried valley (fig. 10) could not be determined with certainty from previous data characterizing the MAS (Curry et al., 1991). The valley appears to extend southward through the Casey municipal well field (Battelle Memorial Institute and Hanson Engineers, Inc., 1990b).

The Martinsville buried bedrock valley joins the North Fork Embarras bedrock valley at two locations: Section 31, T11N, R13W, south and west of the MAS as previously mapped by Curry et al. (1991; see fig. 5), and Sections 6 and 7, T10N, R13W in northern Martinsville. We have informally named the segments of the Martinsville bedrock valley, the northern segment, western segment, and southern segment (fig. 10). A persistent basal alluvium (Martinsville sand) occurs in the North Fork Embarras bedrock valley and the three segments of the Martinsville bedrock valley, indicating that the two valleys are interconnected. Data have not been collected to determine whether additional valley connections are south of Martinsville or north of the MAS.

The drainage network of the buried bedrock valleys may be deranged, possibly because of a regional anastomosing pattern (fig. 10). The genesis of a potentially deranged drainage network in the bedrock is speculative. Anastomosing or interconnecting valleys have been mapped in large bedrock valleys filled with glacial drift, such as the Teays-Mahomet bedrock valley system (Kempton et al., in press), and in smaller bedrock valley segments in Illinois (Vaiden and Curry, 1991) and elsewhere. Deranged patterns are relatively common surficial features along valleys that received discharge from glacial meltwater or glacial lake outbursts (Schumm and Brakenridge, 1987), such as the Mississippi, Illinois, and Wabash River valleys. Deranged patterns result from blockages (local damming), superposed stream segments, and stream piracy.

The apparent deranged bedrock valley network appears to have developed during the pre-Illinoian in subglacial or proglacial environments. Distribution of pre-Illinoian diamicton and sorted sediment south, west, and east of the study area (MacClintock, 1929; Ford, 1970; Johnson et al., 1972; Kettles, 1980; Curry et al., 1989, 1991) indicates that the area had been covered by pre-Illinoian ice, and erosion may have occurred in subglacial or ice marginal environments, or both.

Drift Thickness

The thickest drift south of the MAS occurs in the southern segment of the Martinsville buried bedrock valley, and is at least 180 feet thick in core F-1 (fig. 11). In this study the thinnest drift, 71 feet thick, is in core H-1, compared with a minimum thickness of 20 feet in core M-120 immediately northwest of the MAS (Curry et al., 1991; fig. 11 in this report).

Quaternary Lithostratigraphy

Martinsville Sand

Martinsville sand has three distinct facies composed of sand and gravel, loam diamicton, and silty clay (Curry et al., 1991). The Martinsville sand occurs in all cores south of the MAS, except core A-1, that penetrated glacial drift below bedrock elevations of about 480 ft. All three facies of the Martinsville sand were found in cores C-1, D-1, E-1, F-1, and G-1 (figs. 6 to 9). In these cores, the average thickness of the three facies is 10.3 ft (Battelle Memorial Institute and Hanson Engineers, Inc., 1990b). As at the MAS, the sand and gravel facies predominates, and is as much as 22.9 feet thick in core C-1. The diamicton and silty clay facies together are less than 10.0 feet thick in cores south of the MAS. The lithofacies of the Martinsville sand are typical of an alluvial-colluvial-lacustrine valley-fill deposit in a stream valley not receiving glacigenic sediment.

Thin layers in the sand and gravel facies of the Martinsville sand were observed to be cemented with sesquioxides. The genesis of the cemented zones probably is related to the reduction of iron and manganese that may have occurred in either wetland pedogenic or diagenetic environments. Negligible evidence for pedogenesis, such as pedogenic structure and vermiculite, and the presence of carbonate and chlorite, favor a diagenetic origin. Also supporting a diagenetic origin of these cements is the relatively rich presence of iron and manganese species, dissolved carbon, and methane in groundwater from the Martinsville sand. The poorly expressed pedogenic fea-

tures, in addition to abundant conifer wood fragments, indicate that the Martinsville sand accumulated under cool climate at the beginning of the Illinoian age.

A three-day aquifer test indicated hydrological continuity of the sand and gravel facies of the Martinsville sand along the northern segment of the Martinsville bedrock valley (Battelle Memorial Institute and Hanson Engineers, Inc., 1990b). The hydrological continuity of the Martinsville sand along and between the other segments of bedrock valleys was not tested.

Petersburg Silt

Petersburg Silt, composed of uniform to laminated silt and loam, is thin (less than 1.3 feet thick) or absent in all cores south of the MAS (figs. 6 to 9). Since the gradient of the ancient bedrock valley was southward (fig. 10), Petersburg Silt apparently was deposited in a slackwater lake or low gradient stream that shoaled towards a slackwater lake. Slackwater environments probably occurred as the level of glacial meltwater and sedimentation rose in the ancient Wabash River valley. As an analogy, Late Wisconsinan slackwater sediment, mapped as Equality Formation and deposited in ancient Lake Embarras (Frye et al., 1972), occurs about 20 miles south of Martinsville in the valley of the Embarras River (Lineback, 1979).

Petersburg Silt, as much as 50.4 ft at boring M-125 (fig. 8), is thickest in the northern segment of the Martinsville bedrock valley and generally less than 1.5 feet thick in other segments and the North Fork Embarras buried bedrock valley. It is not known whether the thickness and distribution resulted from the initial depositional thickness or from subsequent erosion by Illinoian glacial ice. The latter hypothesis is preferred given the abundant inclusions of Petersburg Silt within the overlying Smithboro Till Member of the Glasford Formation.

Glasford Formation

Smithboro Till Member The Smithboro Till Member is composed of silt loam to loam diamicton, and commonly contains wood fragments and rare gastropod shells, especially where it is silty. Smithboro diamicton occurs in all cores except core H-1, where it appears to pinch out over a bedrock high (figs. 7 and 8). The thickest Smithboro south of the MAS overlies buried bedrock valleys (fig. 12) and is as much as 76 feet thick in core D-1. The lithology and thickness of the Smithboro, as described at the MAS, persist southward to Martinsville; however, the two facies of the Smithboro are segregated between the two buried bedrock valleys. The loam diamicton facies (>25% sand in the <2 mm fraction) is thickest and most continuous in the Martinsville buried bedrock valley (fig. 8); the silt loam diamicton facies (<25% sand in the <2 mm fraction) is most common in the North Fork Embarras bedrock valley (fig. 7). Comparison of laboratory data from Smithboro sequences reveals the two facies differ in particle-size, sorting, and semi-quantitative clay mineralogy. The loam diamicton facies of the Smithboro from core D-1 (fig. 13) is sandier, more poorly sorted, and contains more illite and less expandable clay minerals than the silt loam diamicton facies of the Smithboro from core C-1 (fig. 14).

Curry et al. (1991) note that although the silt loam diamicton facies of the Smithboro Till Member is easily distinguished visually and by using laboratory data from the overlying Vandalia Till Member, the loam diamicton facies of the Smithboro can often be difficult to differentiate from the uniform diamicton facies of the Vandalia Till Member. The two facies are visually similar, and laboratory data of the Smithboro generally fall within the normal range of Vandalia data (table 1). The units are stratigraphically separable in cores B-1 and D-1, however, because of the presence of the Pike Soil in the upper Smithboro and lower Mulberry Grove Member, respectively. The top of the Smithboro in core B-1 contains fractures with oxidized cutans. Unaltered clay minerals and calcareous diamicton in this zone indicate that the upper part of the soil was truncated, leaving only the lower part of the C horizon (C3 horizon of Follmer, 1984) of the Pike Soil. The lower part of the Mulberry Grove Member in core D-1 (fig. 13) is composed of soft, gleyed diamicton, interpreted to be a Bg horizon of the Pike Soil. This material, as well as the upper Smithboro, is calcareous and contains about 10 precent more expandable clay minerals than the overlying Vandalia and lower Smithboro. Chlorite, however, was not altered to vermiculite, indicating that

the increase in expandable minerals is a primary composition caused by weathering of primary minerals (Willman et al., 1966).

Stratigraphic relationships suggest that the silt loam facies of the Smithboro was deposited before the loam facies during the same glacial advance (Curry et al., 1991). Where the two facies occur together, the basal facies generally is composed of the silt loam diamicton that becomes sandier and grades upwards to the loam diamicton (cores B-1 and G-1, for example; see appendix). The conformable gradational contact between the two facies suggests they were deposited during a single glacial advance. Where the upper part of thick sequences of Smithboro is dominated by the loam diamicton facies, relatively thin layers of the silt loam facies occur with abrupt, easily visible contacts. The abrupt contacts are interpreted to be shear planes caused by deformation and inclusion of Petersburg Silt or the silt loam diamicton facies of the Smithboro. The loam facies in core D-1 closely resembles the overlying Vandalia Till Member, but it contains about 10 percent less sand, and is less poorly sorted (fig. 13). The stratigraphic interpretation is confirmed by the presence of the Pike Soil in the intervening Mulberry Grove Member.

Mulberry Grove Member The Mulberry Grove Member comprises three easily distinguishable facies composed of sand and gravel, diamicton and silt (Curry et al., 1991). The composition, thickness, distribution of the Mulberry Grove south of the MAS follow patterns described at the MAS by Battelle Memorial Institute and Hanson Engineers, Inc. (1990a,b) and Curry et al. (1991). The thickest and most continuous layers of the sand and gravel facies generally are coincident with buried bedrock valleys, especially the North Fork Embarras buried bedrock valley (figs. 3 to 9). The thickest Mulberry Grove Member (about 58 feet) encountered in the study area is in core C-1 (fig. 15). The thickness of two layers of sand and gravel facies in this core totals 36 feet. The layers of granular sediments are separated by a 12-foot thick layer of the diamicton facies (fig. 14). We correlated this diamicton bed at C-1 with a layer of Mulberry Grove Member that possibly occurs continuously along the North Fork Embarras bedrock valley, and generally is less than 10 feet thick (figs. 7 and 16). Battelle Memorial Institute and Hanson Engineers, Inc. (1990b) correlate the diamicton layer and underlying sand and gravel with the Vandalia Till Member . The location of core C-1 corresponds with the approximate confluence of the southern segment of the Martinsville buried valley and North Fork Embarras buried bedrock valley. The lowest bedrock elevation (418 ft) in the study area also was noted in core C-1. The thickest sand and gravel facies, about 35 feet, occurs in core A-1 (fig. 16). The sand and gravel facies, about 10 to 15 feet thick, occurs in cores D-1 and F-1 along the southern segment of the Martinsville bedrock valley (figs. 8 and 13).

The new borings indicate a few notable characteristics of the Mulberry Grove along the North Fork Embarras bedrock valley. Because of potential groundwater interaction, it is worth noting that a 30-foot-thick sand and gravel facies is in contact with bedrock in core H-1 (fig. 7), a situation not noted in other borings described by Battelle Memorial Institute and Hanson Engineers, Inc. (1988, 1990a) or Curry et al. (1991). A persistent layer of the diamicton facies is sandwiched by the sand and gravel facies of the Mulberry Grove (fig. 7, Section E-E′; fig. 16). Interpretation of this diamicton layer as laterally continuous is strengthened by differing geochemical and piezometric data from the overlying and underlying sand and gravel layers (Battelle Memorial Institute and Hanson Engineers, Inc., 1990b). These data indicate that groundwater in the upper sand and gravel unit interacts with groundwater in Cahokia Alluvium, whereas groundwater in the lower sand and gravel layer is geochemically distinct from groundwater in other units (Battelle Memorial Institute and Hanson Engineers, Inc., 1990b). The persistent diamicton and thick sand and gravel layers occupy a paleochannel eroded in the Smithboro Till Member along the North Fork Embarras bedrock valley (fig. 17). The channel morphology is evident in a segment of cross section E-E′ that is drawn perpendicular to the buried valley axis through borings M-127, M-126, and M-110 (fig. 7). Because of the general coincidence of the North Fork Embarras River valley and its buried bedrock valley counterpart, a thick sand and gravel facies likely occurs in this channel along any cross-valley profile across the modern North Fork Embarras River valley in the study area.

Additional evidence from this study indicate that the Mulberry Grove was deposited in subaerial environments, especially the aforementioned Pike Soil interval in the base of the Mulberry Grove in core D-1 (fig. 13). A map showing sedimentary environments based on facies sequences of the Mulberry Grove was extended south of the MAS (fig. 18). The map is compiled from sparse information compared with the MAS database. The map depicting the elevation of the base of the Vandalia Till Member (fig. 19) shows much less relief than the map depicting the elevation of the base of the Mulberry Grove (fig. 17), indicating that the Mulberry Grove filled in low areas on the Smithboro paleotopography. Figure 19 shows that deviations from a nearly flat-lying surface occur especially above bedrock highs, and where the Vandalia Till truncates thick sequences of underlying units.

Vandalia Till Member The Vandalia Till Member consists of loam diamicton that regionally has a distinct particle-size distribution and mineralogy (Kettles, 1980; Curry et al., 1991). The Vandalia also contains interbeds of sand and gravel. The Vandalia at the MAS consists of two facies, composed of uniform diamicton and mèlange. The mèlange facies consists of three distinct lithologies including primarily diamicton, less sand and gravel, and subordinate silt (Curry et al., 1991). The composition and thickness of the uniform diamicton and mèlange facies of the Vandalia Till Member south of the MAS generally are similar to those at the MAS. The thickest uniform diamicton facies occurs under present-day uplands, and is as much as 65 feet thick in core B-1 (fig. 20). The thinnest uniform diamicton occurs in modern valleys, and is between 5 to 15 feet thick in the North Fork Embarras River valley (figs. 3 to 9). South of the MAS, the thickest mèlange facies (28 feet) is in core M-107 (Battelle Memorial Institute and Hanson Engineers, Inc., 1990a,b; Curry et al., 1991). In general, the mèlange facies is thinner south of the MAS than on the site, and absent in the larger valleys (fig. 21).

Compared with mèlange facies at the MAS, the mèlange facies south of the MAS contains less sand (37.9% vs. 45.4%) and more expandable clay minerals (18.2% vs. 11.5%). The differences probably are due to analyses of inclusions of weathered sediment in the mèlange facies south of the MAS that were not observed in cores from the MAS. The largest inclusion of weathered sediment, about 3 feet thick, was observed in core A-1 (fig. 22). The uniform diamicton facies and mèlange facies are somewhat more poorly sorted and contain more gravel south of the MAS than the Vandalia diamicton at the site. The greater percentage of coarser fragments south of the MAS possibly is related to glacial erosion and entrainment of coarse fragments along bedrock slopes most resistant to glacier flow.

Curry et al. (1991) discuss anomalously low elevations of the base of the Vandalia Till Member that occur in the area of CLK-02-03 at the MAS and coincide with truncated sequences of Smithboro Till and Petersburg Silt (figs. 3, 4 and 19). The base of the Vandalia also is anomalously low in the area of core M-107 just south and west of the MAS (fig. 9); this feature may be a shallow depression or valley in the upper surface of the Mulberry Grove and Smithboro units (fig. 19; see also fig. 7-13 in Battelle Memorial Institute and Hanson Engineers, Inc., 1990a). In areas around CLK-02-03 and M-107, the sand and gravel facies of the Mulberry Grove Member occurs below the anomalously thick Vandalia, bringing the Mulberry Grove closer to the Martinsville sand in those areas than elsewhere on or near the MAS.

Pearl Formation

Pearl Formation, composed of chiefly pedogenically altered sand and gravel, has limited distribution at the MAS (Curry et al., 1991) and was not noted in any cores taken for this study.

Berry Formation

The Berry Formation, composed of pedogenically altered soft, gleyed, leached loam diamicton, occurs in all upland borings in this study (A-1, B-1, D-1, F-1 and G-1), and in previously described upland borings on or near the MAS (Battelle Memorial Institute and Hanson Engineers, Inc., 1990a,b; Curry et al., 1991). The thickest Berry Formation (10 ft) occurs in core D-1. The thick-

ness and distribution south of the MAS are similar to patterns noted at the MAS (Curry et al., 1991).

Roxana Silt

The sandy silt facies of the Roxana Silt, composed of pedogenically altered, soft silt loam to loam, is either thin or absent in cores south of the MAS.

Peoria Loess and Parkland Sand

Peoria Loess, the surficial unit across upland surfaces in the study area, is composed of pedogenically altered, soft, leached silt loam to silty clay loam. The loess is as much as 2.6 feet thick in core G-1. Parkland Sand, composed of well-sorted medium-grained sand, is absent in cores south of the MAS except for core M-113 (fig. 9). The uppermost part of upland cores B-1 and D-1 (fig. 3), taken in disturbed areas, are composed of local fill.

Peyton Colluvium and Lacon Formation

The thickness and distribution of Peyton Colluvium and Lacon Formation are not addressed in this report.

Cahokia Alluvium

The thickness and distribution of Cahokia Alluvium are shown in figure 23. In this report we subdivide the Cahokia into a lower sand and gravel facies and an upper silt loam facies because of their distinct lithology and general consistency of stratigraphic position (fig. 7). The sand and gravel facies, composed of uniform to stratified coarse-grained sediment, possibly correlates with the Henry Formation that was deposited by proglacial streams associated with the Late Wisconsinan Shelbyville Moraine, 8 miles north of the MAS. The silt loam facies is composed of pedogenically altered, soft, leached, uniform to vaguely laminated silt loam in the North Fork Embarras River valley. The facies is sandier in the valleys of Bluegrass Creek and the Kettering Branch. The silt loam facies is interpreted to have originated as overbank sediment that interfingers with colluvium, especially adjacent to valley slopes. Cross section E-E′ (fig. 7) shows the remarkably continuous lower layer of the sand and gravel facies and the upper layer of the silt loam facies in the Cahokia along the North Fork Embarras River.

DISCUSSION AND CONCLUSIONS

The lithostratigraphic units at the Martinsville Alternative Site, described in Battelle Memorial Institute and Hanson Engineers, Inc. (1990a, b) and Curry et al. (1991), correlate with units that occur south of the MAS, including those that occur within Martinsville's municipal water-well field. Martinsville's water supply is pumped from thick sand and gravel facies of the Mulberry Grove Member of the Glasford Formation. Geochemical analyses indicate that water from the overlying Cahokia Alluvium mixes with water as it is pumped from the Mulberry Grove (Battelle Memorial Institute and Hanson Engineering, 1990b).

The stratigraphic sequence revealed in core A-1 (fig. 22) exemplifies the deposits at the Martinsville water well field. From base to top, the Quaternary lithostratigraphic succession includes about:

a) 5 feet of olive gray (5Y 4/2; Munsell notation) silty clay and loam diamicton of the Martinsville sand;

b) 23 feet of dark grayish brown (2.5Y 4/2) to gray (5Y 5/1) silt loam diamicton of the Smithboro Till Member of the Glasford Formation;

c) 6 feet of gray (5Y 5/1 to N 5/0) loam diamicton of the Mulberry Grove Member;

d) 30 feet of gray (N 5/0 to 10YR 5/1) sand and gravel of the Mulberry Grove Member;

e) 5 feet of gray (N 5/0) uniform loam diam icton of the Vandalia Till Member;

f) 11 feet of yellowish brown (10YR 5/4) to gray (2.5Y 5/1) loam to clay loam diamicton of the mèlange facies of the Vandalia Till Member;

g) 19 feet of gray (N 5.5/0) to brown (10YR 5/3) sand and gravel of the Cahokia Alluvium.

The mèlange facies of the Vandalia Till Member contains an inclusion of weathered sediment, probably Lierle Clay, that is not commonly observed in the mèlange facies. Identification of the Mulberry Grove Member is verified by its relative stratigraphic position between diamictons with compositions typical of the uniform diamciton facies of the Vandalia Till Member above, and silt loam diamciton facies of the Smithboro Till Member below. Stratigraphic interpretations of boring logs from the Martinsville water well field are presented in Battelle Memorial Institute and Hanson Engineers, Inc. (1990b).

Paleochannels along the bedrock valley network possibly provide two physical connections for the sand and gravel facies of the Mulberry Grove Member between the MAS and the Martinsville well field. The sand and gravel facies of the Mulberry Grove is thickest and most continuous above the buried bedrock valleys. One route joins the western segment of the Martinsville bedrock valley with the North Fork Embarras bedrock valley just south and west of the Martinsville Alternative Site; the North Fork Embarras bedrock valley continues south to the well field. Aquifer tests and piezometric data indicate that the sand and gravel facies of the Mulberry Grove is discontinuous in the western segment of the Martinsville bedrock valley (Battelle Memorial Institute and Hanson Engineers Inc., 1990b). Cores and groundwater data indicate a thick, continuous Mulberry Grove Member along the length of the North Fork Embarras River bedrock valley. The Martinsville muncipal water wells occur on the west flank of the North Fork Embarras buried bedrock valley where the sand and gravel facies of the Mulberry Grove Member is about 35 feet thick.

The Mulberry Grove along the North Fork Embarras bedrock valley is composed of at least one bed of diamicton sandwiched between layers of sand and gravel (fig. 7). The overlying layer of Vandalia Till may be discontinuous (as indicated from geochemical data) because groundwater in the basal sand of the Cahokia Alluvium has mixed with groundwater in the upper sand layer of the Mulberry Grove (fig. 7; Battelle Memorial Institute and Hanson Engineering, 1990b). The supporting data include the results from numerical groundwater modeling and chemical analyses of the groundwater (i.e., tritium content, radiocarbon activity, major and minor ion content; Battelle Memorial Institute and Hanson Engineers, Inc., 1990b).

The second route that may connect the sand and gravel facies of the Mulberry Grove between the MAS and the Martinsville well field is along the southern segment of the Martinsville bedrock valley. Because this route appears to follow a single, linear segment of the bedrock valley segment (fig. 10), it is more direct than the route discussed above. However, the sand and gravel facies of the Mulberry Grove Member is thinner (about 15 feet) than it is along the first route (about 34 feet). Chemical analyses and numerical groundwater modeling suggest relatively slow lateral groundwater movement within the Mulberry Grove Member in this area. Therefore, groundwater in the Mulberry Grove in the southern segment of the Martinsville bedrock valley probably supplies very little groundwater to the Martinsville water wells compared with groundwater in the North Fork Embarras bedrock valley. A more rigorous treatment of the data and an ensuing discussion are presented in Battelle Memorial Institute and Hanson Engineers, Inc. (1990b).

Cahokia Alluvium is thick and continous beneath the valley of the North Fork Embarras River. In this valley the Cahokia is composed of an upper silt loam facies and a lower sand and gravel facies. In tributary valleys of the North Fork Embarras River valley, the lithology of the Cahokia Alluvium includes a sandy variant of the silt loam facies. In the North Fork Embarras River valley, the sand and gravel facies may correlate with the Henry Formation, a unit that regionally was deposited as surficial Late Wisconsinan outwash.

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APPENDIX

Location and laboratory data for cores (Battelle Memorial Institute and Hanson Engineers, 1990c).

Key to listing of laboratory data

Unit symbol	Unit
l	Lacon Formation
c	Cahokia Alluvium
pey	Peyton Colluvium
p	Peoria Loess
pks	Parkland Sand
r	Roxana Silt, sandy silt facies
b	Berry Formation
pe	Pearl Formation
	Glasford Formation
	Vandalia Till Member
gv-m	mélange facies
gv-u	uniform diamicton facies
	Mulberry Grove Member
gm-d	diamicton facies
gm-z	sand and gravel facies
gm-s	silt facies
	Smithboro Till Member
gs	loam diamicton facies
gs-s	silt loam diamicton facies
ps	Petersburg Silt
	Martinsville sand
ms-d	diamicton facies
ms-z	sand and gravel facies
ms-s	silty clay facies
	Banner Formation
bl	Lierle Clay Member
bc	Casey till member
Plm, Pb	Modesto or Bond Formation

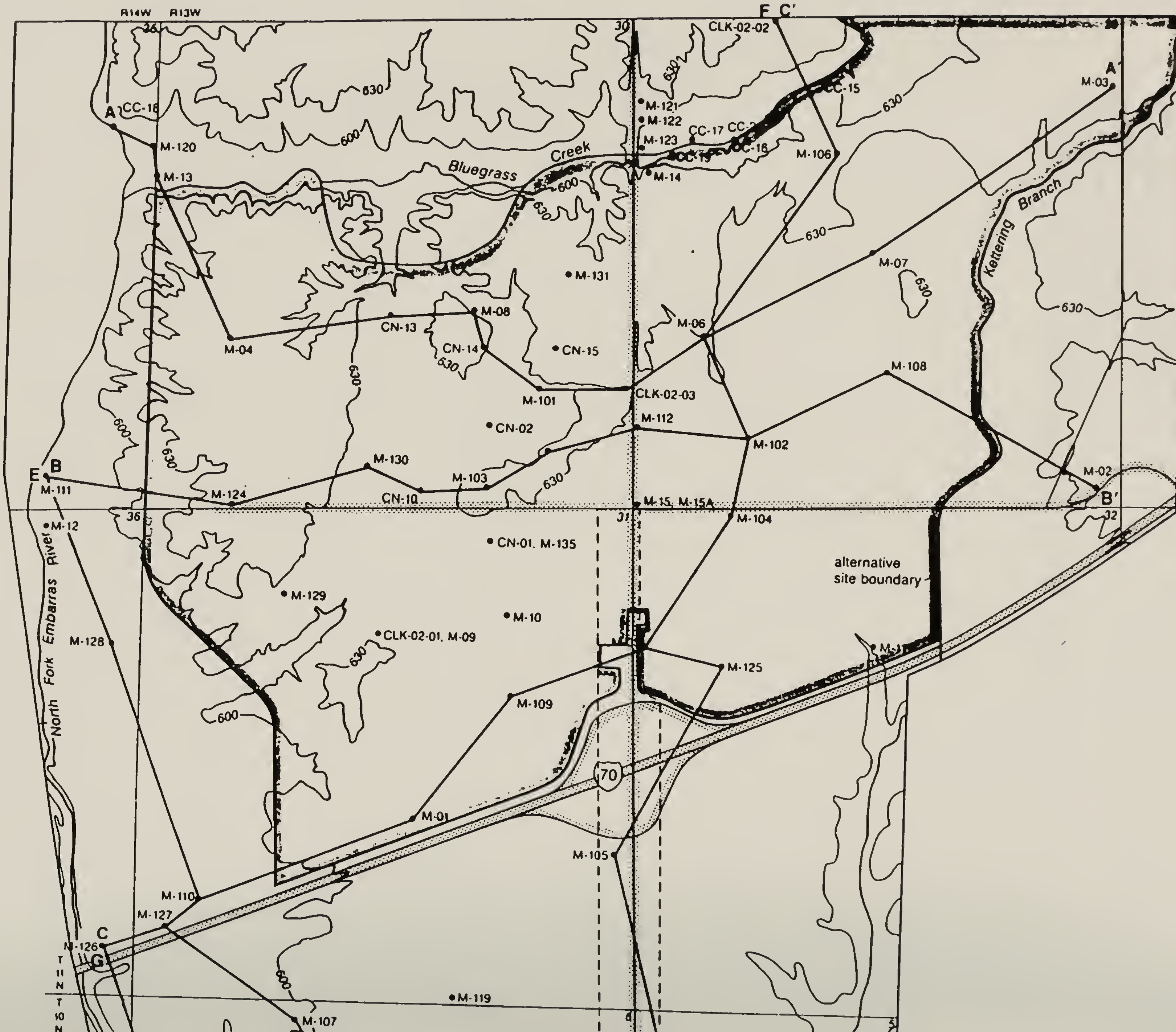
Suffixes

-o oxidized (e.g. bc-o = oxidized Casey Till Member; C1, C2 or C3 horizon of Sangamon or Yarmouth Soils)
-x significant pedogenic alteration (B horizon of Sangamon or Yarmouth Soils)
-z sand and/or gravel inclusive of unit

Column headings

Tot gvl = total gravel in subsample (> 2000 μm)
mm fraction, SD% = sand (63-2000 μm)
mm fraction, ST% = silt (4-63 μm)
mm fraction, CL% = clay (<4 μm)
Cu = coefficient of uniformity
W% = moisture content
LL = liquid limit
PL = plastic limit
PI = plasticity index
EXP = expandable clay minerals
ILL = illite

C-K = chlorite plus kaolinite; note that EXP + IL + C-K = 100%
Cal = calcite (in counts per second)
Dol = dolomite (in counts per second)
VERM IND = vermiculite index
DI = diffraction intensity ratio
HSI = heterogeneous swelling index
INT CPS = total counts per second, uncorrected, for EXP + IL + C-K


R14W
R13W
Bluegrass
Creek
Kettering
Branch
North Fork Embarras River
alternative
site boundary
M-03
M-07
M-06
M-108
M-102
M-104
M-02
M-106
CLK-02-02
CLK-02-03
CLK-02-01, M-09
M-121
M-122
M-123
M-14
M-120
M-13
M-04
M-08
CN-13
CN-14
CN-15
M-131
M-101
M-112
CN-02
M-130
M-103
M-124
CN-10
M-111
M-12
M-15, M-15A
CN-01, M-135
M-129
M-10
M-128
M-125
M-109
M-01
M-105
M-110
M-127
M-126
M-119
M-107
70
630
600

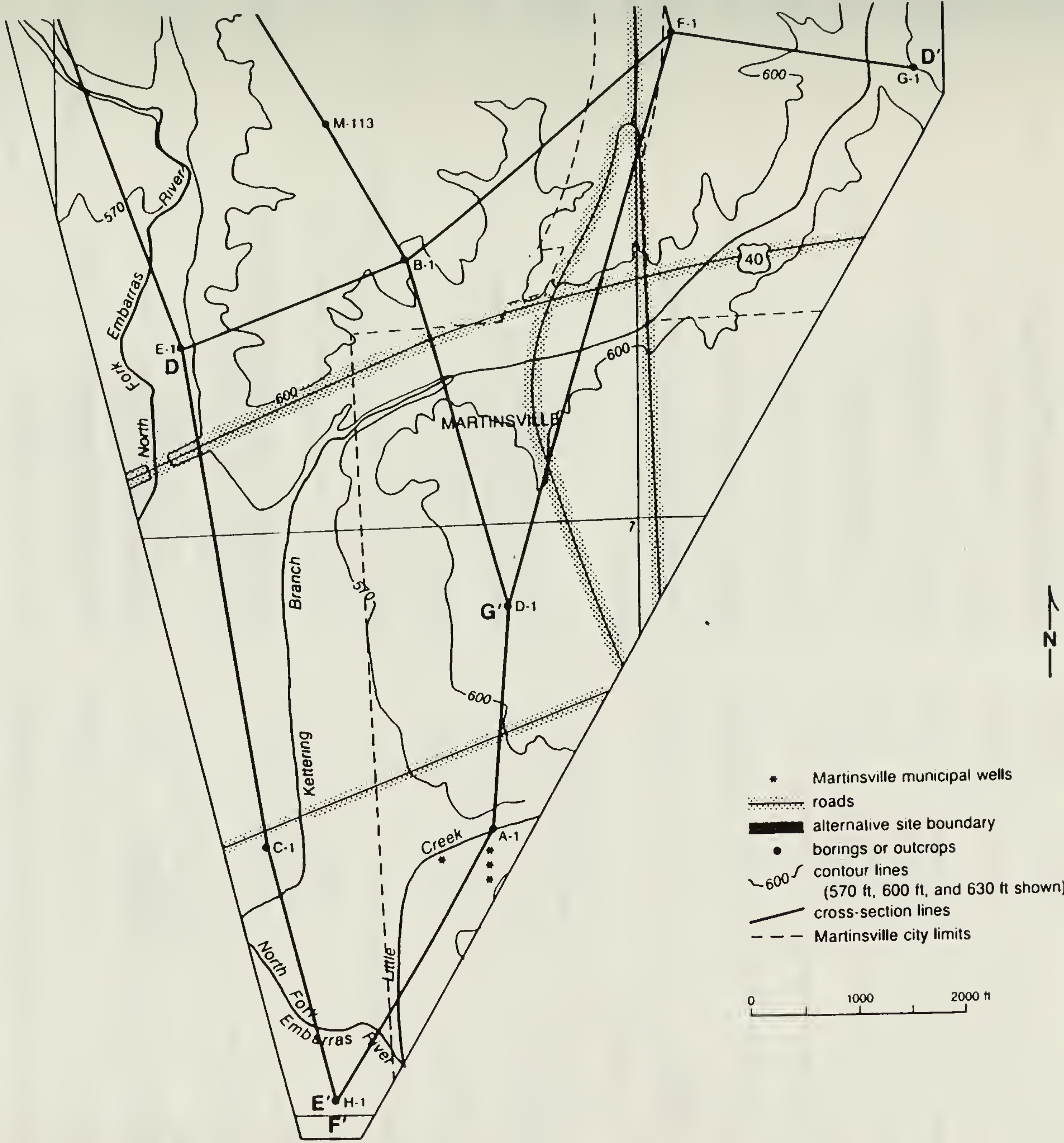


Figure 1 Generalized topography, the Martinsville Alternative Site (MAS), streams, and locations of borings studied in Curry et al. (1991) and this study. Lines of section for figures 3 to 9 also are shown.

Init (symbol)	Age	*Pedostrati-graphic unit	Color of fresh core or outcrop (Munsell notation)
acon Formation (l)	Holocene	Modern	Grayish brown (10YR 5/2), yellowish brown (10YR 5/4)
'eyton Colluvium (pey)	Wisconsinan, Holocene	Modern	Graylsh brown (10YR 5/2), Brownish yellow (10YR 6/6)
:ahokia Alluvium (c)	Holocene, Wisconsinan	Modern	Grayish brown (2.5Y 5/2), gray (N 4/0), yellowish brown (10 YR 5/4), dark gray (10YR 4/2)
'arkland Sand (pks)	Wisconsinan	Modern	Very pale brown (10YR 7/3), light gray (N 6/0)
'eoria Loess (p)	Wisconsinan	Modern	Light brownish gray (10YR 6/2), very pale brown (10YR 7/3), dark grayish brown (10YR 4/2), light gray (2.5Y 7/2), black (10YR 2/1)
ɿoxana Silt (r)	Wisconsinan	Farmdale	Light pinkish gray (7.5YR 6/1), yellowish brown (10YR 5/8), black (N 2/0)
3erry Formation (b)	late Illinoian, Sangamonian	Sangamon	Dark gray (2.5Y 4/1), gray (N 6/0), pinkish gray (7.5YR 6/2), grayish brown (10YR 5/2), black (N 2/0)
'earl Formation (pe)	late Illinoian	Sangamon	As above, and strong brown (7.5YR 4/6)
Glasford Formation	Illinoian		
Vandalia Till Mbr.			
mélange facies (gv-m)			Gray (N 5/0)
as above, B-horizon of Sangamon Soil (gv-mx)	-	Sangamon	Grayish brown (10YR 5/2), brownish yellow (10YR 6/6), red (2.5YR 4/8), black (5YR 2.5/1)
as above, C-horizon of Sangamon Soil (gv-mo)	-	Sangamon	Light yellowish brown (2.5Y 6/2), brown (10YR 5/3)
uniform diamicton facies (gv-u)	-		Gray (N 5/0)
Mulberry Grove Member	Illinoian	-	
sand and gravel facies (gm-z)	-		Gray (N 5/0), olive gray (5Y 5/2)
diamicton facies (gm-d)	Pike		Gray (N 5/0), greenish gray (5GY 5/1; rare)
silt loam facies (gm-s)	Pike		Olive gray (5Y 5/2), gray (N 5/0), dark grayish brown (2.5Y 4/2)
Smithboro Till Member	Illinoian		
loam diamicton facies (gs)		Pike (rare)	Gray (N 5/0)
silt loam diamicton facies (gs-s)		-	Gray (N 5/0; 5Y 4/1), very dark gray (10YR 3/1), dark grayish brown (2.5YR 4/2), dark olive grey (5Y 3/2), pale olive (5Y 6/3)
Petersburg Silt (ps)	Illinoian	**	Pale olive (5Y 6/3), dark olive gray (5Y 3/2), black (5Y 2.5/1)
Martinsville sand	early Illinoian		
silty clay facies (ms-s)		**	Greenish gray (5GY 6/1), dark greenish gray (7.5GY 4/1), dark grayish yellow (5Y 4/3), red (10YR 4/6), black (N 2/0)
sand and gravel facies (ms-z)	**		Olive gray (5Y 5/2), grayish brown (2.5Y 5/2)
diamicton facies (ms-d)	-		Olive gray (5Y 4/2)
Banner Formation			
Lierle Clay Member (bl)	Yarmouthian	Yarmouth	Gray (N 5/0), olive gray (5Y 5/2), brown (10YR 5/3)
Casey till member (bc)	pre-Illinoian	-	Gray (N 4.5/0, 5Y 4.5/1)
as above, B-horizon of Yarmouth Soil (bc-x)	-	Yarmouth	Grayish brown (10YR 5/2), yellowish brown (10YR 5/6)
as above, C-horizon of Yarmouth Soil (bc-o)	-	Yarmouth	Light yellowish brown (10YR 6/4)
Modesto and Bond Formations (Pb)	Pennsylvanian	Yarmouth	Light brownish gray (10YR 6/2), very dark grayish brown (2.5Y 3/2), black (N 2/0), for example

*generally, but not necessarily associated with lithostratigraphic unit
**associated with no named soil stratigraphic unit, but possesses leached, organic-rich horizons and fragments of wood
***notation from Buol et al., 1980

Figure 2 Quaternary lithostratigraphy of the Martinsville Alternative Site (modified from Curry et al., 1991).

Plasticity, moist consistence***	Discontinuities	Description (thickness, feet)
Plastic to slightly plastic, friable	Pedogenic; roots, burrows, peds, etc.	Loam diamicton, silt loam (0-4)
Slightly plastic, friable	Pedogenic	Silt loam, loam diamicton (0-4)
Plastic to nonplastic, loose to friable	Pedogenic	Interbedded gravel, fine- to medium-grained sand and silt loam (0-35)
Slightly plastic, very friable	Pedogenic	Fine grained sand (0-7)
Plastic, friable to firm	Pedogenic	Silty clay, silt loam (0-7)
Plastic, firm	Pedogenic, including krotovina, large Mn nodules and concretions	Loam (1-4)
Plastic, firm	Pedogenic as above	Silty clay loam, clay loam, loam diamicton (3-12)
Nonplastic to plastic, loose to firm	Lithologic	Gravelly sand, fine-grained sand, silty clay (0-13)
Slightly plastic, firm to extremely firm	Lithologic: sand-filled joints, healed fractures, and faults	Chiefly loam diamicton, with less gravelly sand, sand, and subordinate silt (0-26)
Plastic, firm	As above, but pedogenically modified	As above, but leached, and with pedogenic features (0-2)
Slightly plastic, firm to extremely firm	As above	As above, but leached along discontinuities, and with pedogenic features (0-10)
Slightly plastic, extremely firm	Lithologic discontinuities as above, but less frequent	Loam diamicton, less amounts of sand and gravel (0-129)
Nonplastic, loose	Lithologic	Sandy loam to sorted sand and gravel (0-31)
Slightly plastic, extremely firm	Lithologic	Loam diamicton (<10)
Slightly plastic to plastic, firm	Lithologic	Silt loam, silt (0-10)
Slightly plastic, firm	Healed fractures, sand-filled joints, infrequent vertical pedogenic cracks	Loam diamicton (0-44)
Slightly plastic to plastic, firm to extremely firm	Horizontal shear planes separating lithologic discontinuities	Silt loam diamicton (0-58)
Nonplastic to slightly plastic, firm	-	Silt loam, silt, fine- to coarse-grained sand (0-50)
Plastic, firm to extremely firm	Lithologic	Silt clay, clay loam (0-4)
Nonplastic, loose	Lithologic	Sand and gravel (0-25)
Plastic, firm	Lithologic	Sandy loam diamicton (0-9)
Plastic, firm	Lithologic	Silty clay, silty clay loam (0-6)
Slightly plastic, extremely firm	Lithologic, including sand-filled joints, healed fractures	Loam, clay loam diamicton (0-30)
Plastic, firm	As above, with pedogenic alteration	As above, but leached and with pedogenic features (0-5)
Slightly plastic, extremely firm	As above, with pedogenic alteration	Loam diamicton (0-5)
Nonplastic to slightly plastic, firm to extremely firm	Lithologic	Sandstone, siltsone, mudstone, limestone, coal

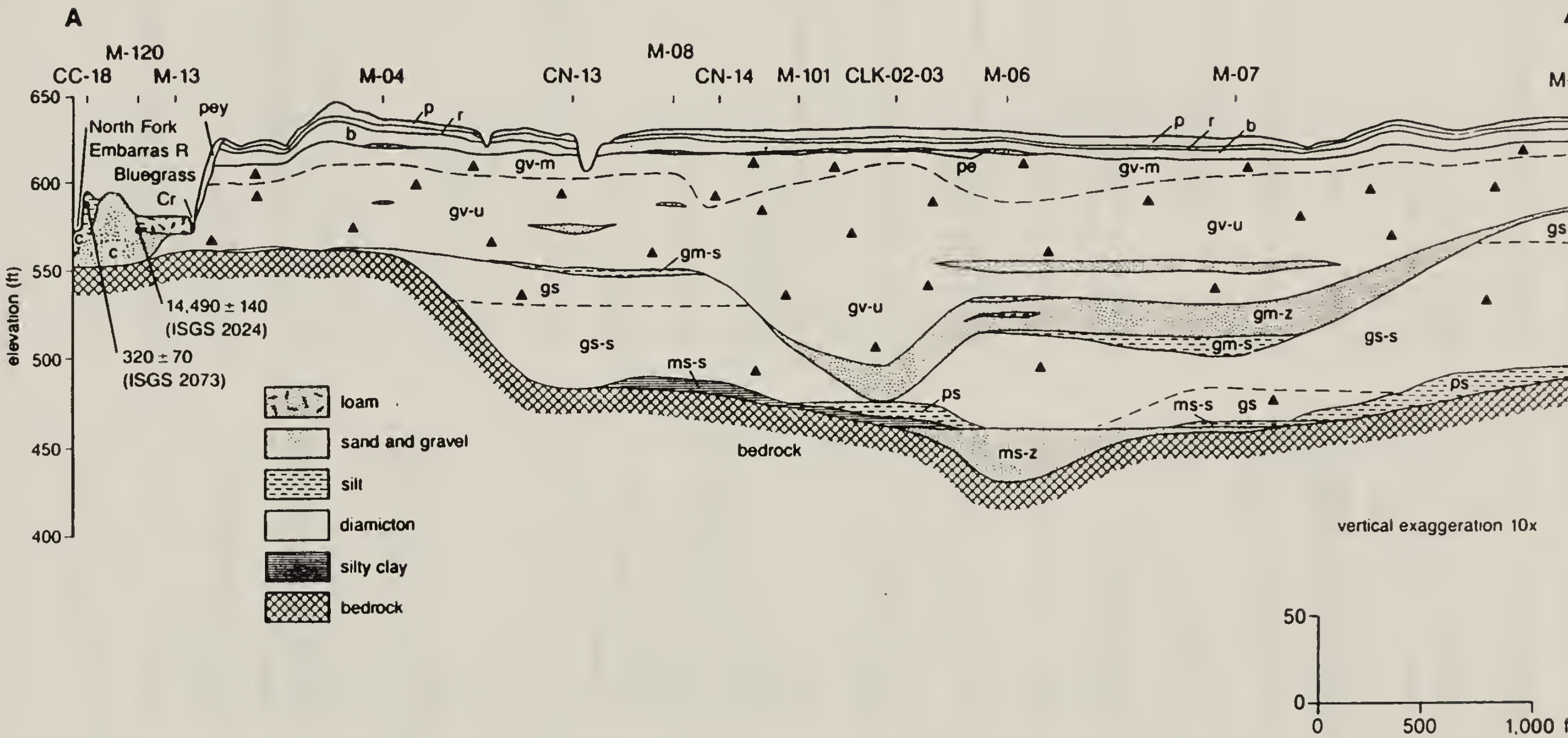


Figure 3 Cross section A-A′. Line of section shown in fig. 1. All borings extend to bedrock (from Curry et al., 1991). Triangles denote the relative abundance of >2 mm fragments per unit.

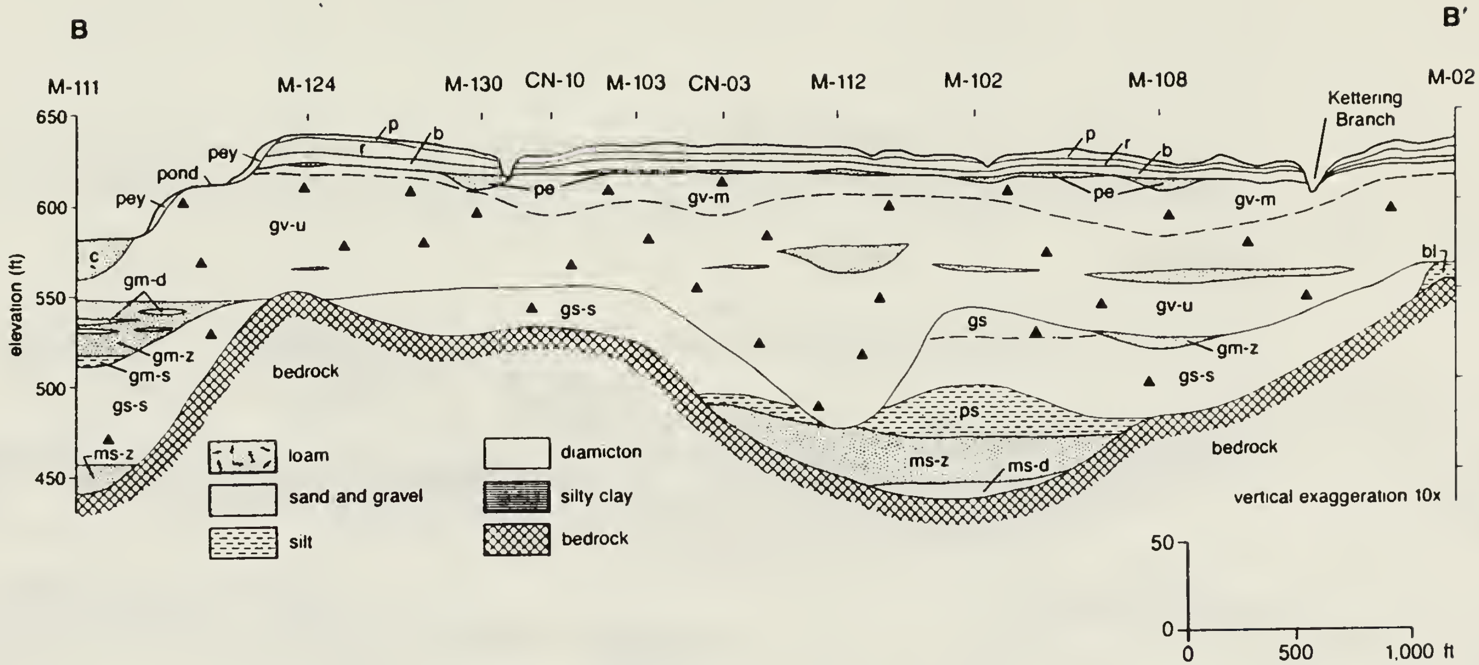


Figure 4 Cross section B-B′. Line of section shown in fig. 1. All borings extend to bedrock (from Curry et al., 1991). Triangles denote the relative abundance of >2 mm fragments per unit.

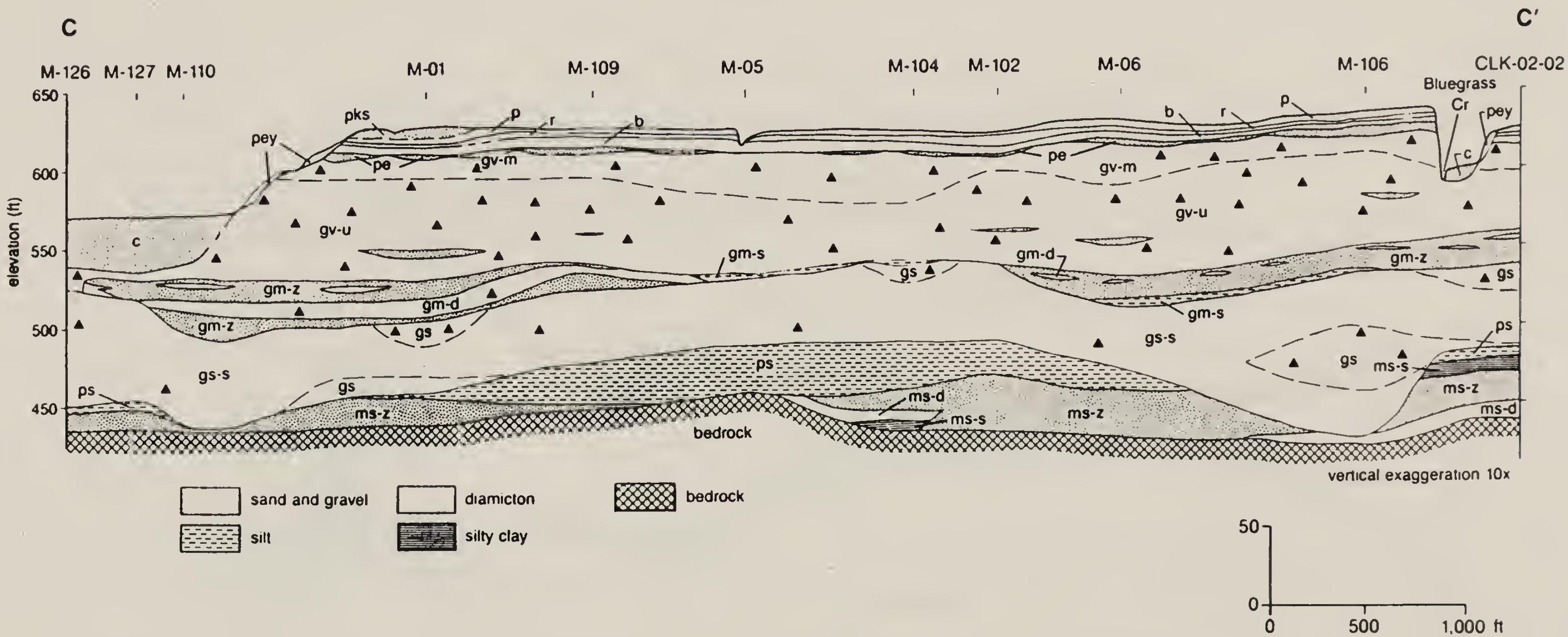


Figure 5 Cross section C-C′. Line of section shown in fig. 1. All borings extend to bedrock except M-127 (from Curry et al., 1991). Triangles denote the relative abundance of >2 mm fragments per unit.

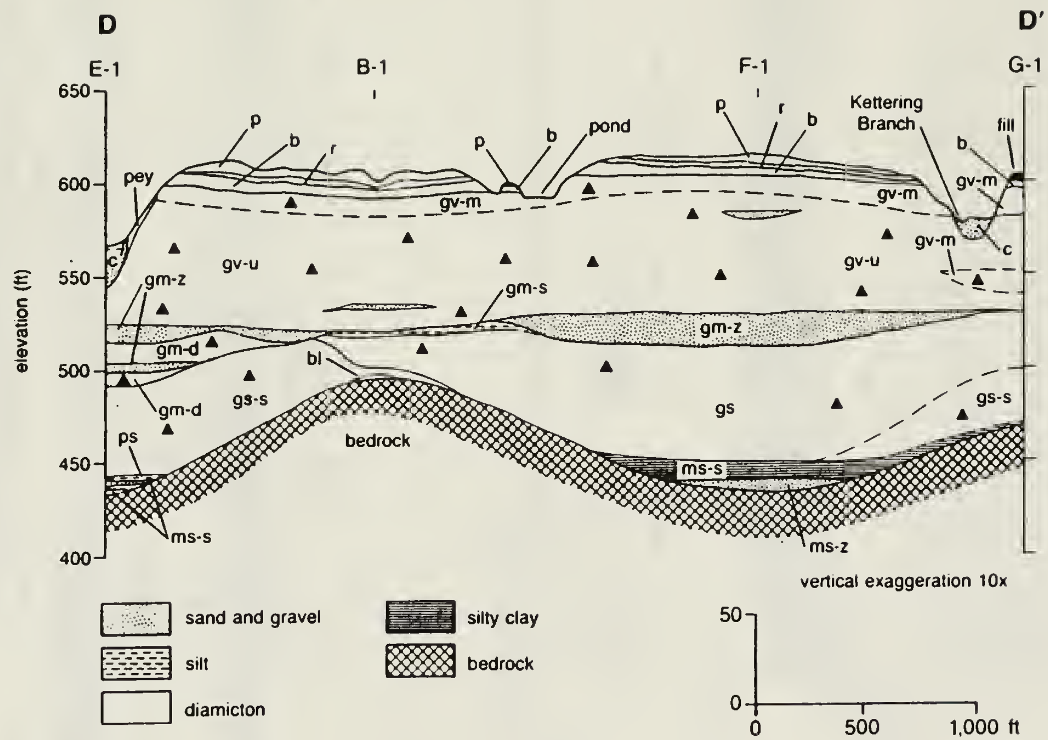


Figure 6 Cross section D-D′. Line of section shown in fig. 1. All borings extend to bedrock. Triangles denote the relative abundance of >2 mm fragments per unit.

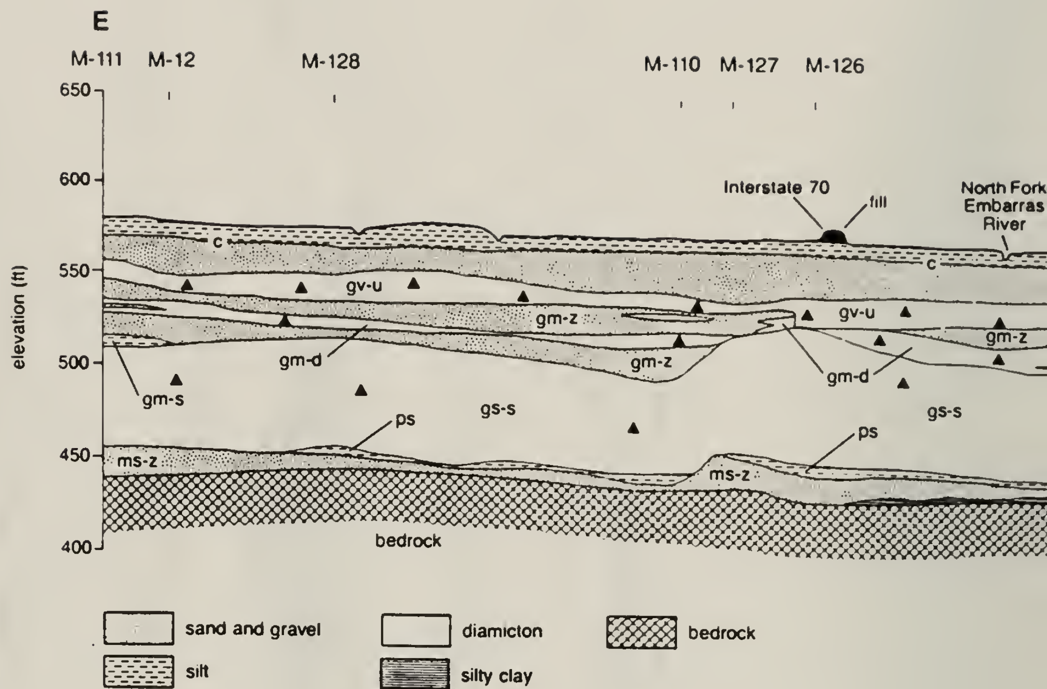


Figure 7 Cross section E-E′. Line of section shown in fig. 1. All borings extend to bedrock. Triangles denote the relative abundance of >2 mm fragments per unit.

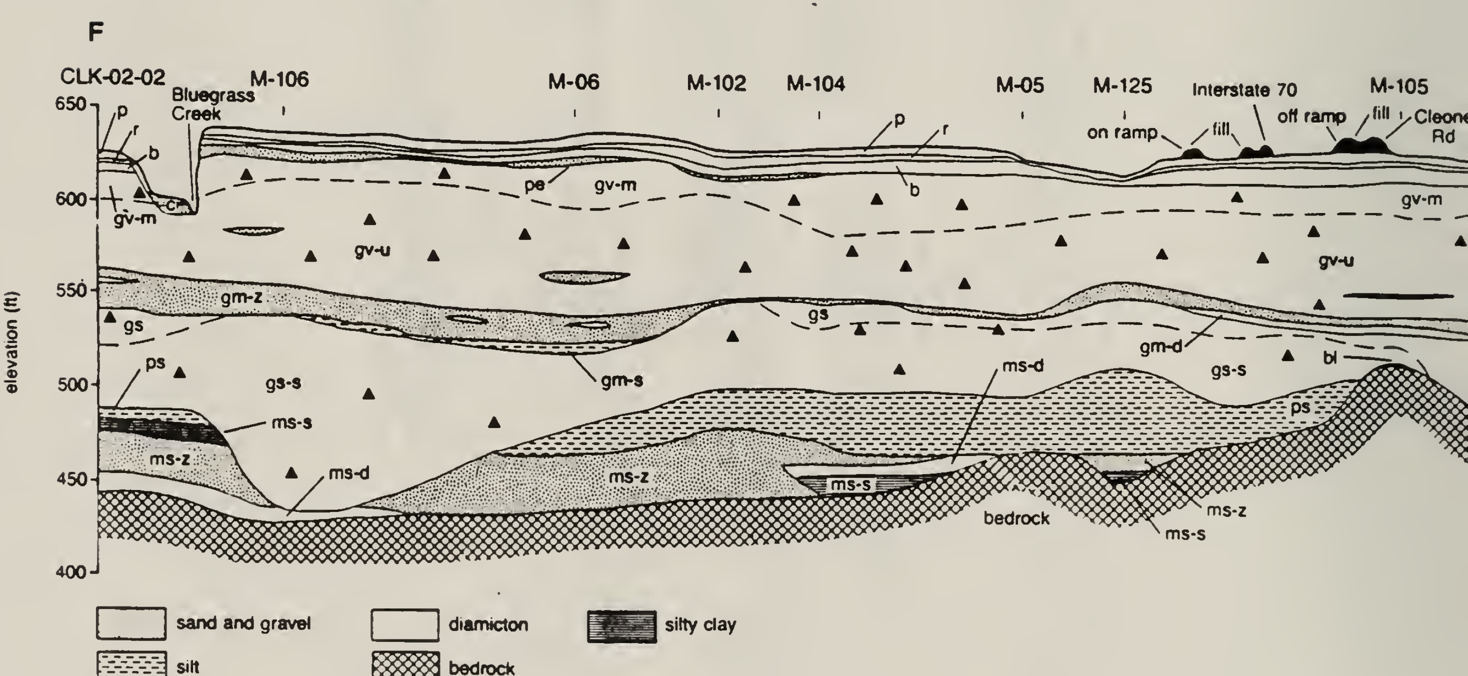
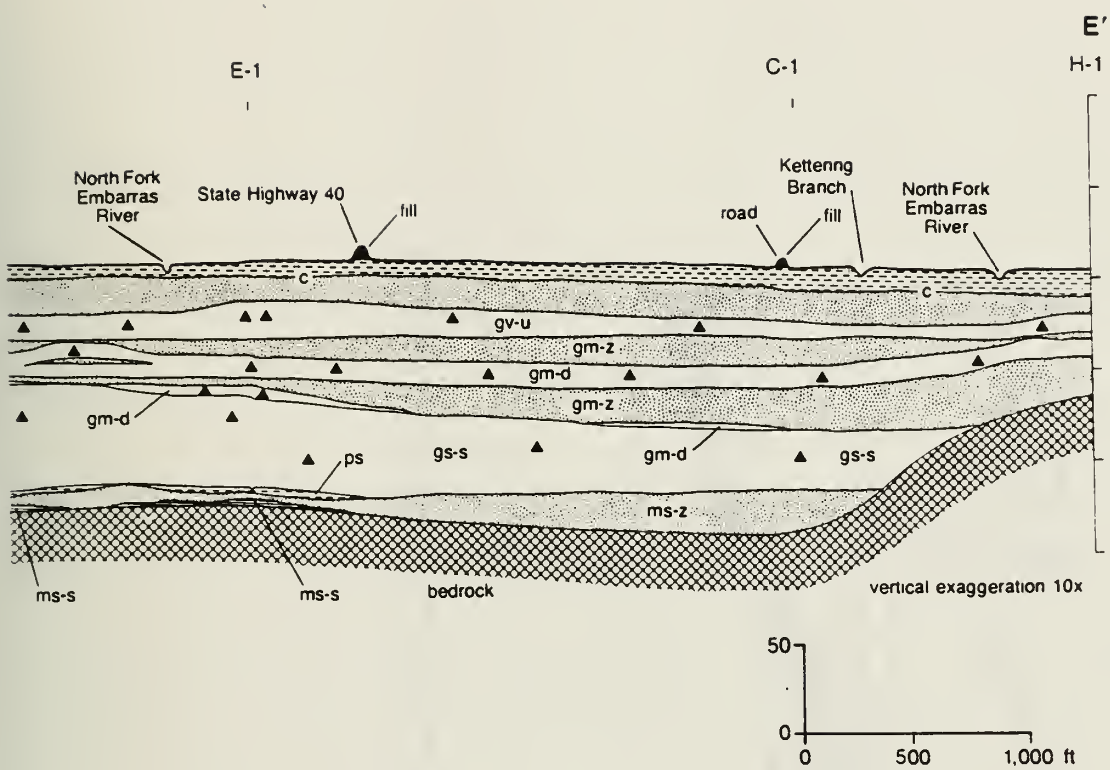
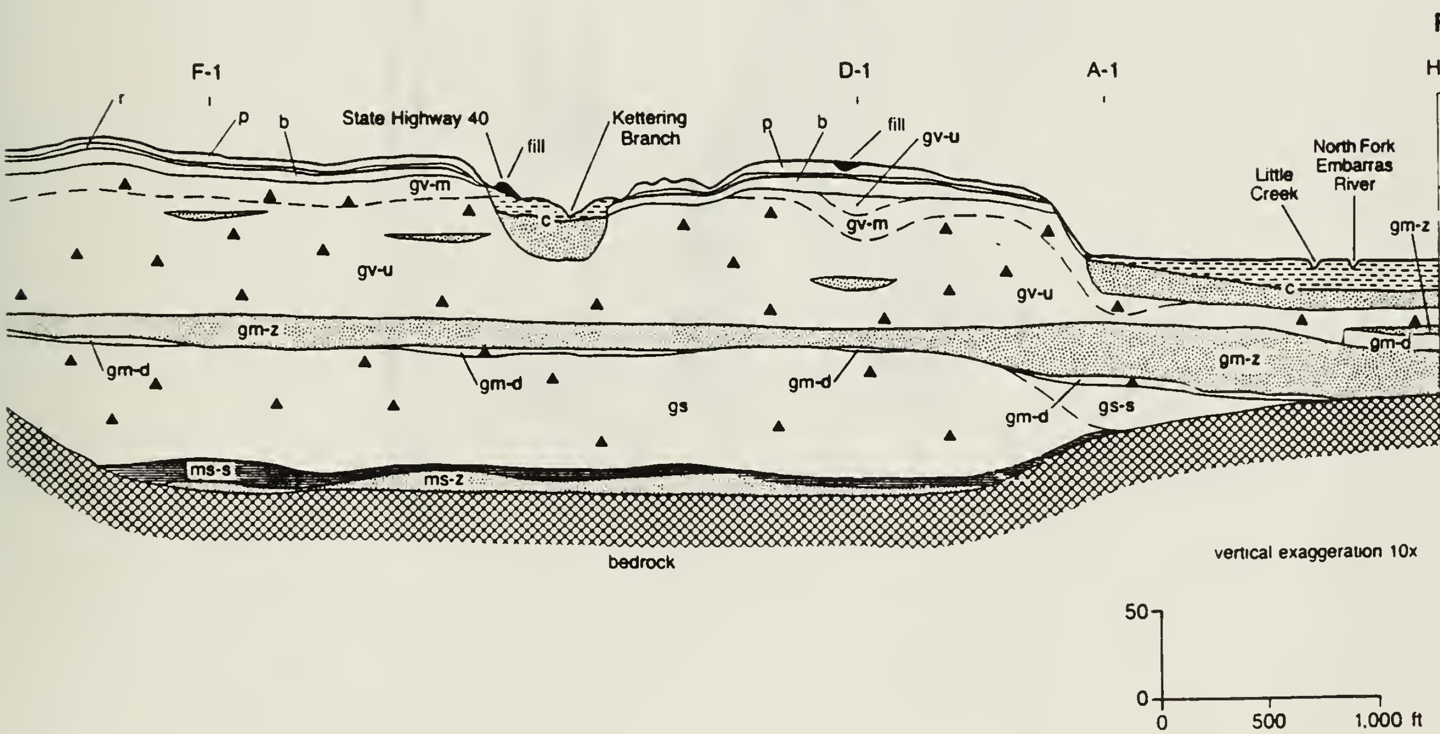


Figure 8 Cross section F-F′. Line of section shown in fig. 1. All borings extend to bedrock. Triangles denote the relative abundance of >2 mm fragments per unit.


E′
E-1
C-1
H-1
North Fork Embarras River
State Highway 40
fill
Kettenng Branch
road
fill
North Fork Embarras River
c
c
gv-u
gm-z
gm-d
gm-z
gm-d
ps
gs-s
gm-d
gs-s
ms-z
ms-s
ms-s
bedrock
vertical exaggeration 10x
50
0
0
500
1,000 ft


F′
F-1
D-1
A-1
H-1
r
p
b
State Highway 40
fill
Kettering Branch
p
b
fill
gv-u
gv-m
c
gv-m
Little Creek
North Fork Embarras River
gm-z
gv-u
gv-u
c
gm-z
gm-d
gm-d
gm-z
gm-d
gm-d
gs
gm-d
gs-s
ms-s
ms-z
bedrock
vertical exaggeration 10x
50
0
0
500
1,000 ft

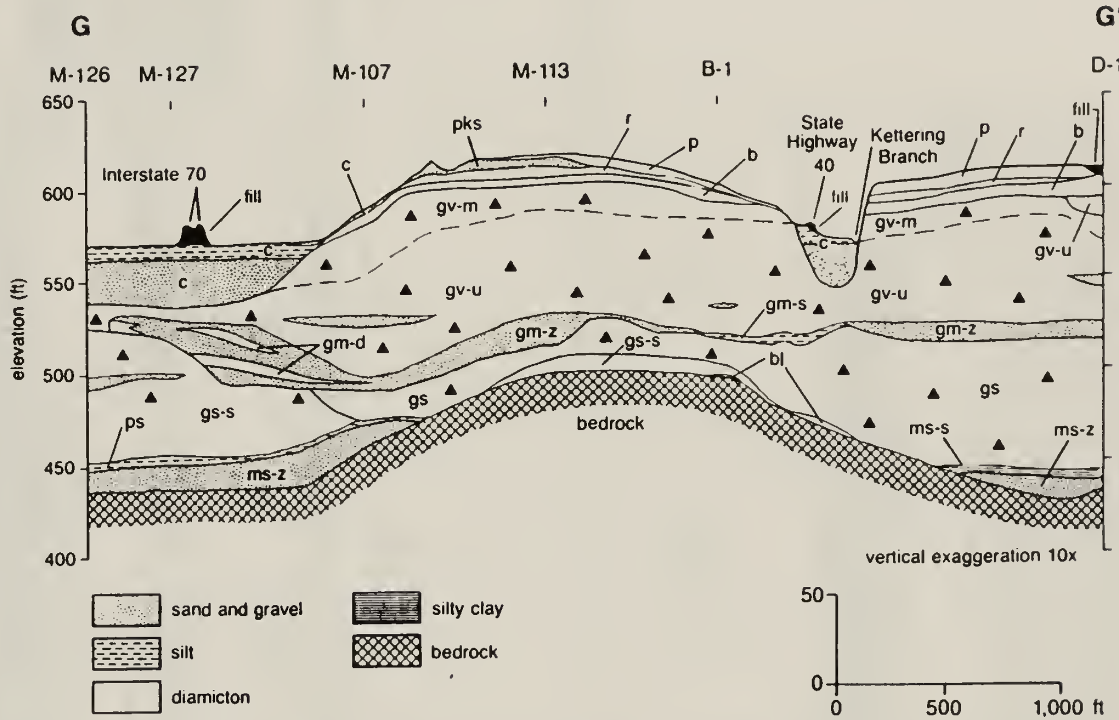
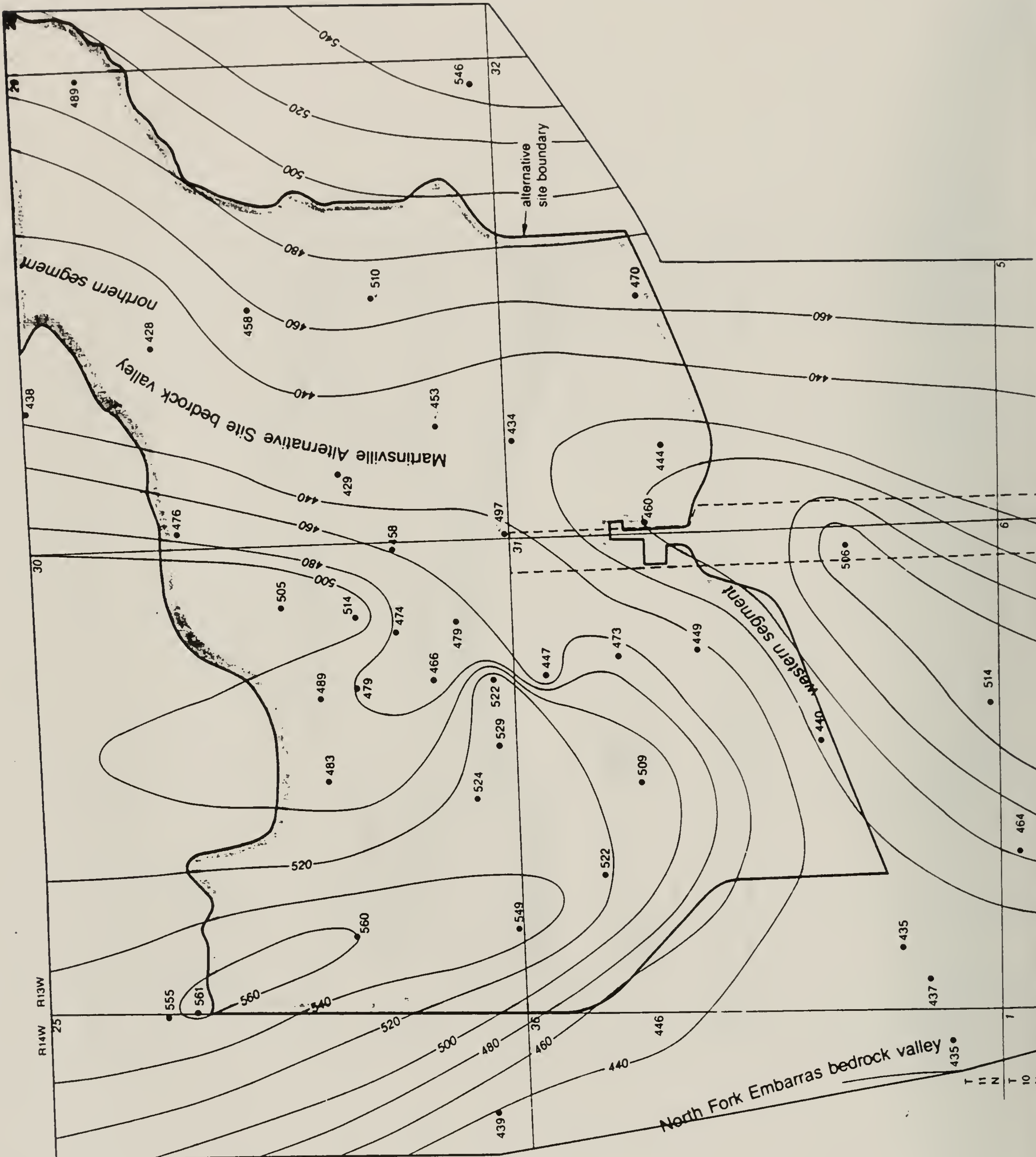


Figure 9 Cross section G-G′. Line of section shown in fig. 1. All borings extend to bedrock. Triangles denote the relative abundance of >2 mm fragments per unit.



Martinsville Alternative Site bedrock valley
northern segment
western segment
alternative site boundary
North Fork Embarras bedrock valley
R14W
R13W
T 11 N
T 10 N
540
520
500
480
460
440
560

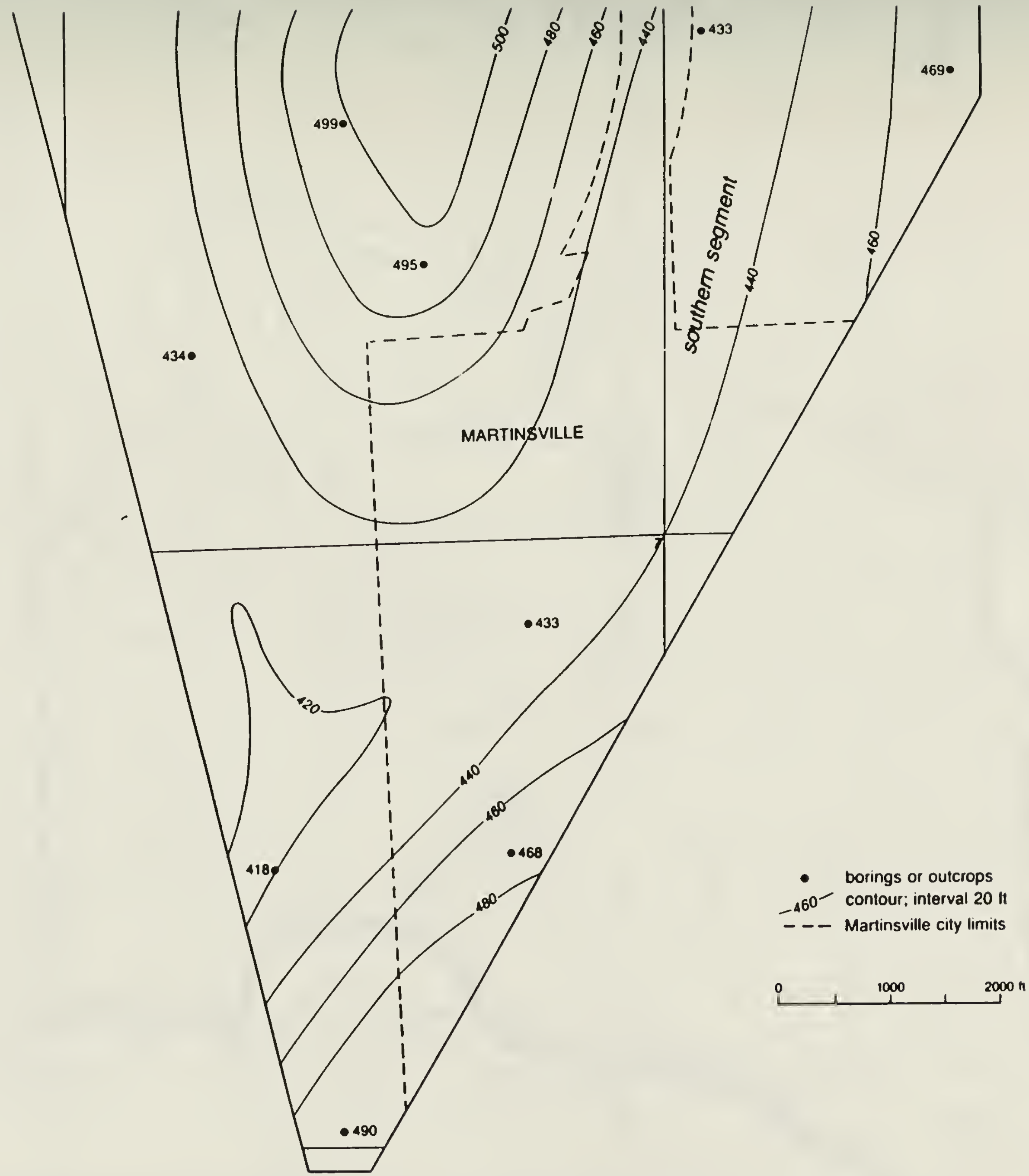
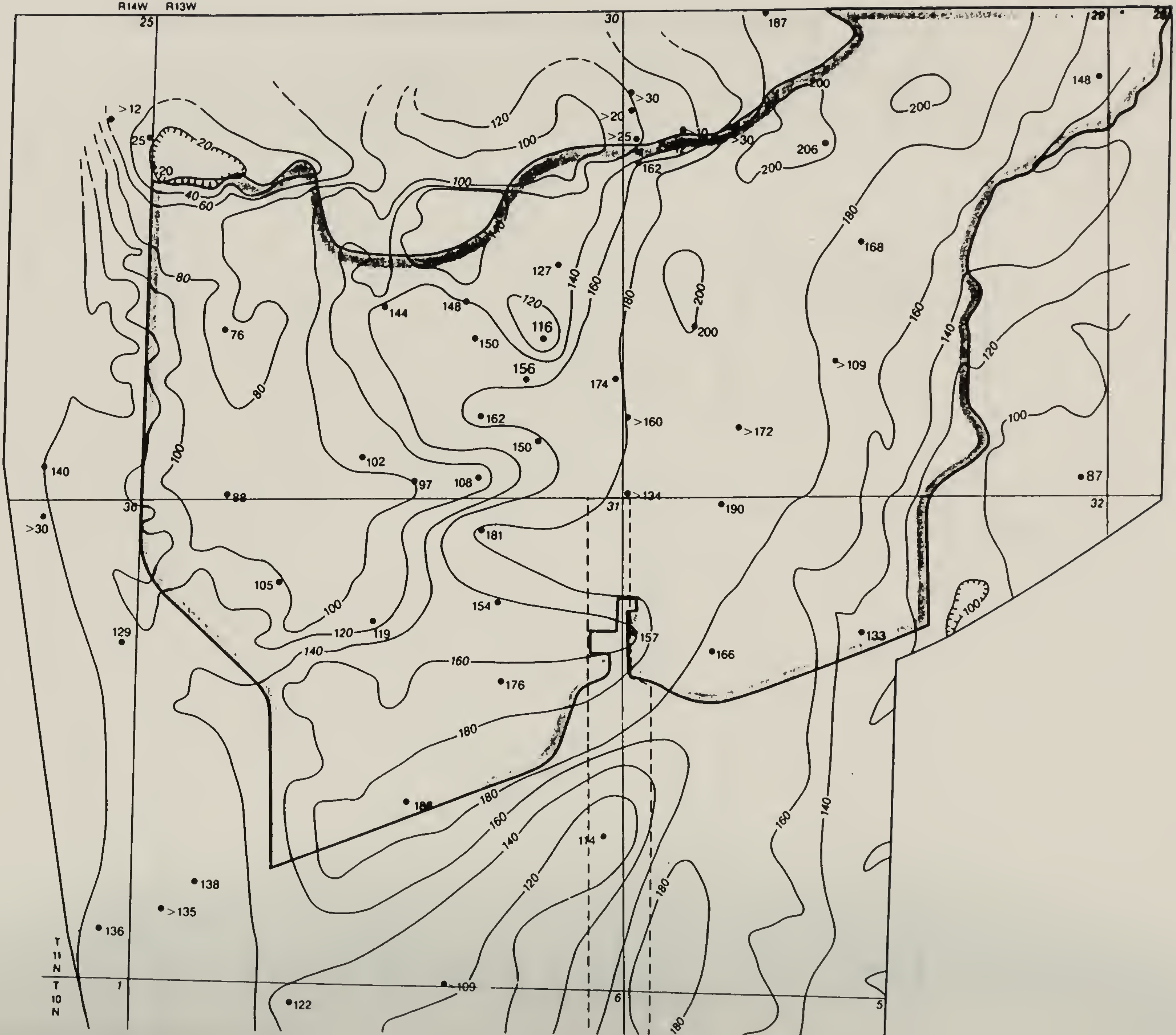


Figure 10 Bedrock topography beneath the study area (modified from Curry et al., 1991).


R14W
R13W
T 11 N
T 10 N

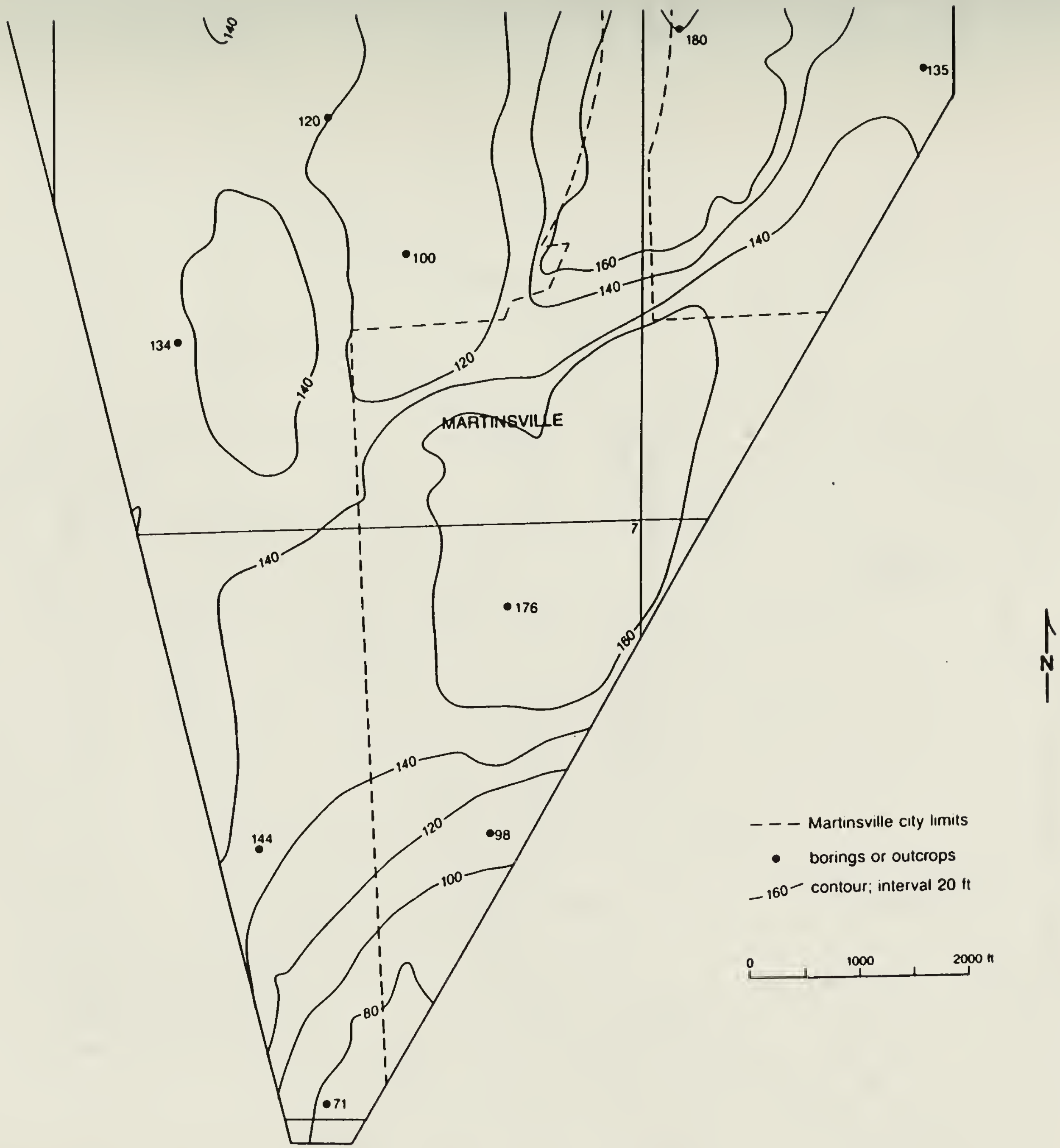
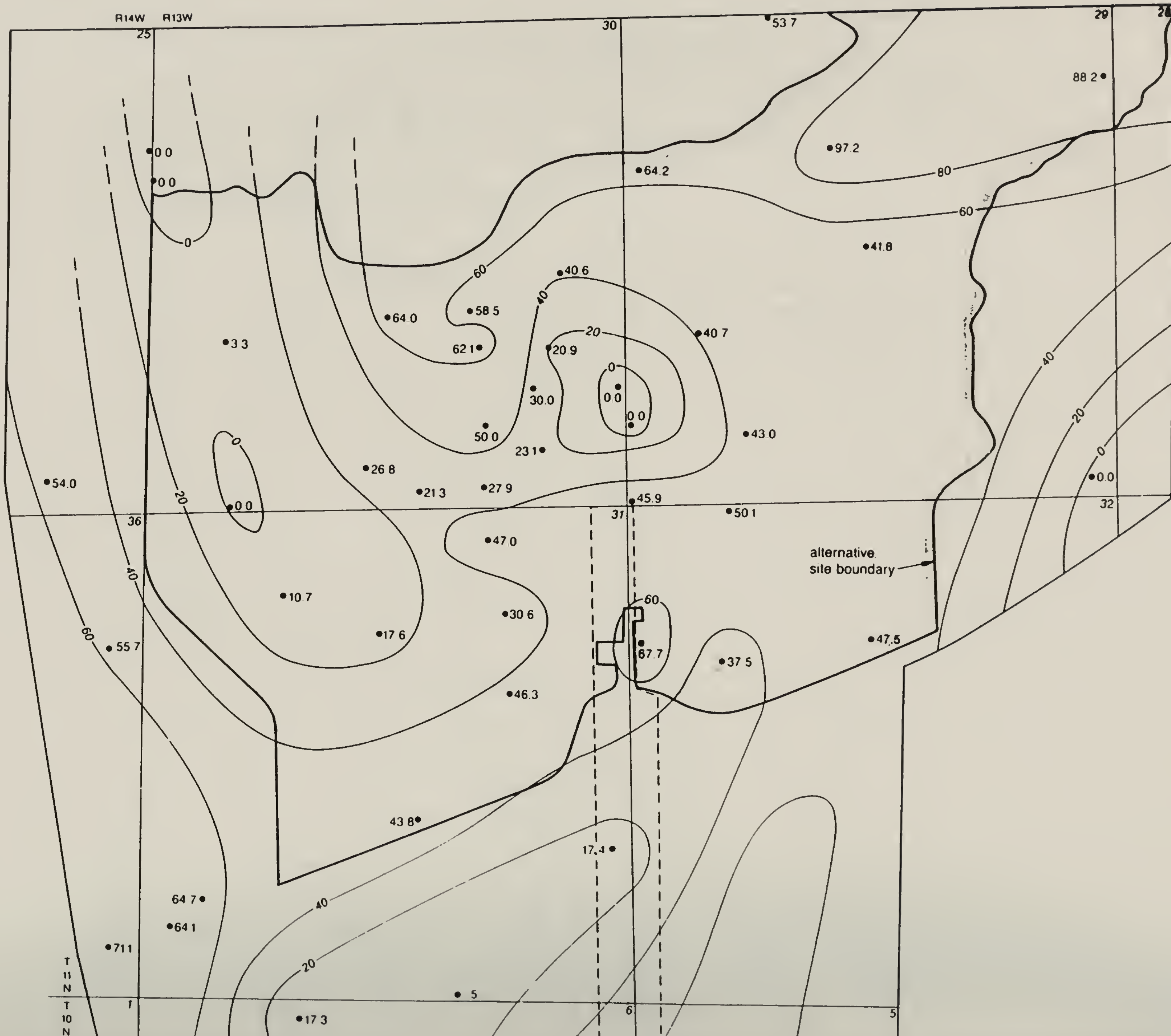


Figure 11 Thickness of glacial drift at the MAS (modified from Curry et al., 1991).



R14W
R13W
25
30
29
28
36
31
32
1
6
5
T 11 N
T 10 N
alternative site boundary
0
20
40
60
80
53 7
88 2
97.2
64.2
41.8
0 0
0 0
40.6
58 5
64 0
62 1
3 3
20.9
30.0
0 0
0 0
40 7
43 0
50 0
23 1
26 8
21 3
27 9
45.9
50 1
0 0
54.0
0.0
47 0
10.7
30 6
17 6
67.7
37 5
47.5
55 7
46.3
43 8
17.4
64 7
64 1
71 1
5
17 3

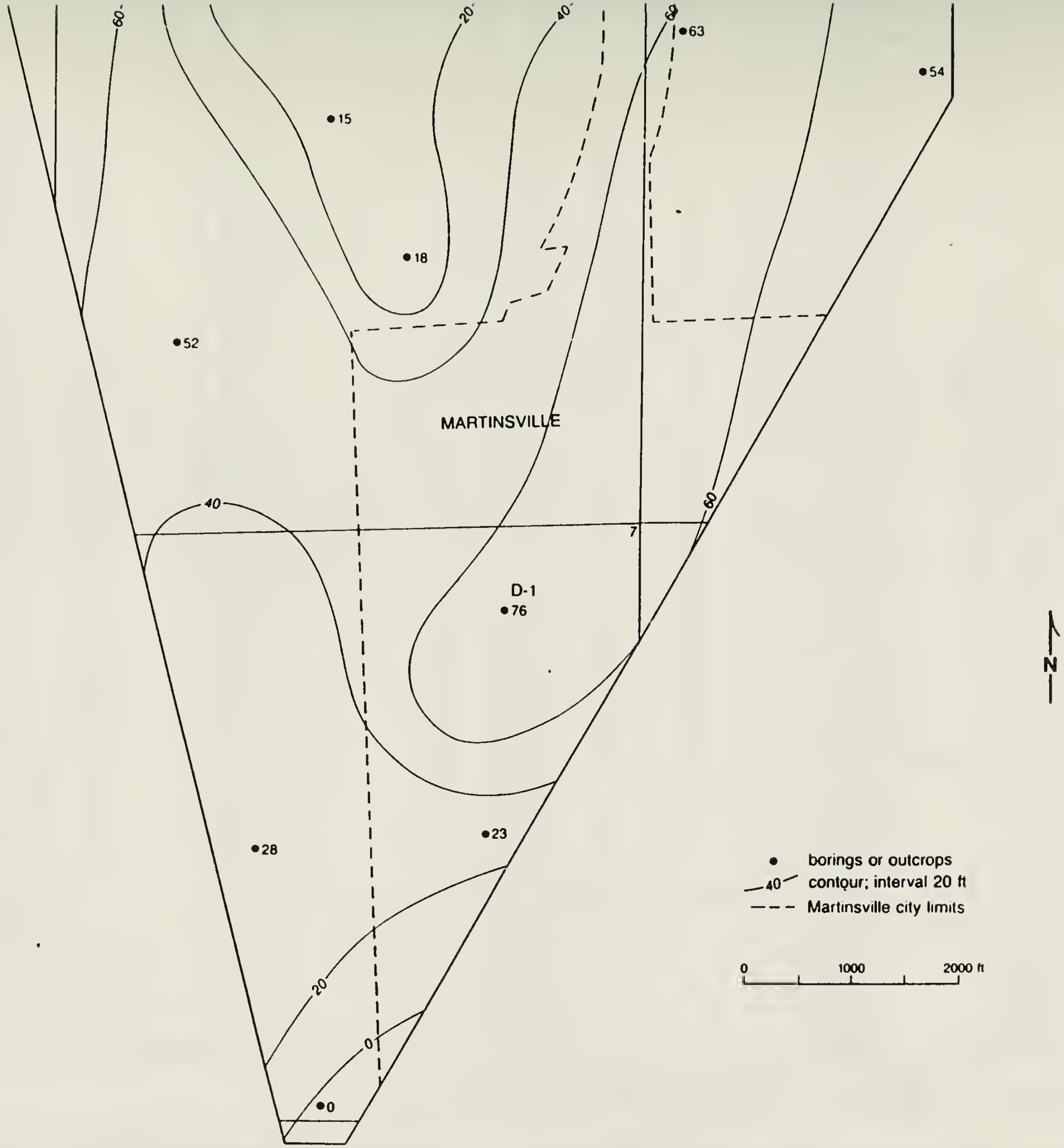


Figure 12 Thickness of the Smithboro Till Member, Glasford Formation (modified from Curry et al., 1991).

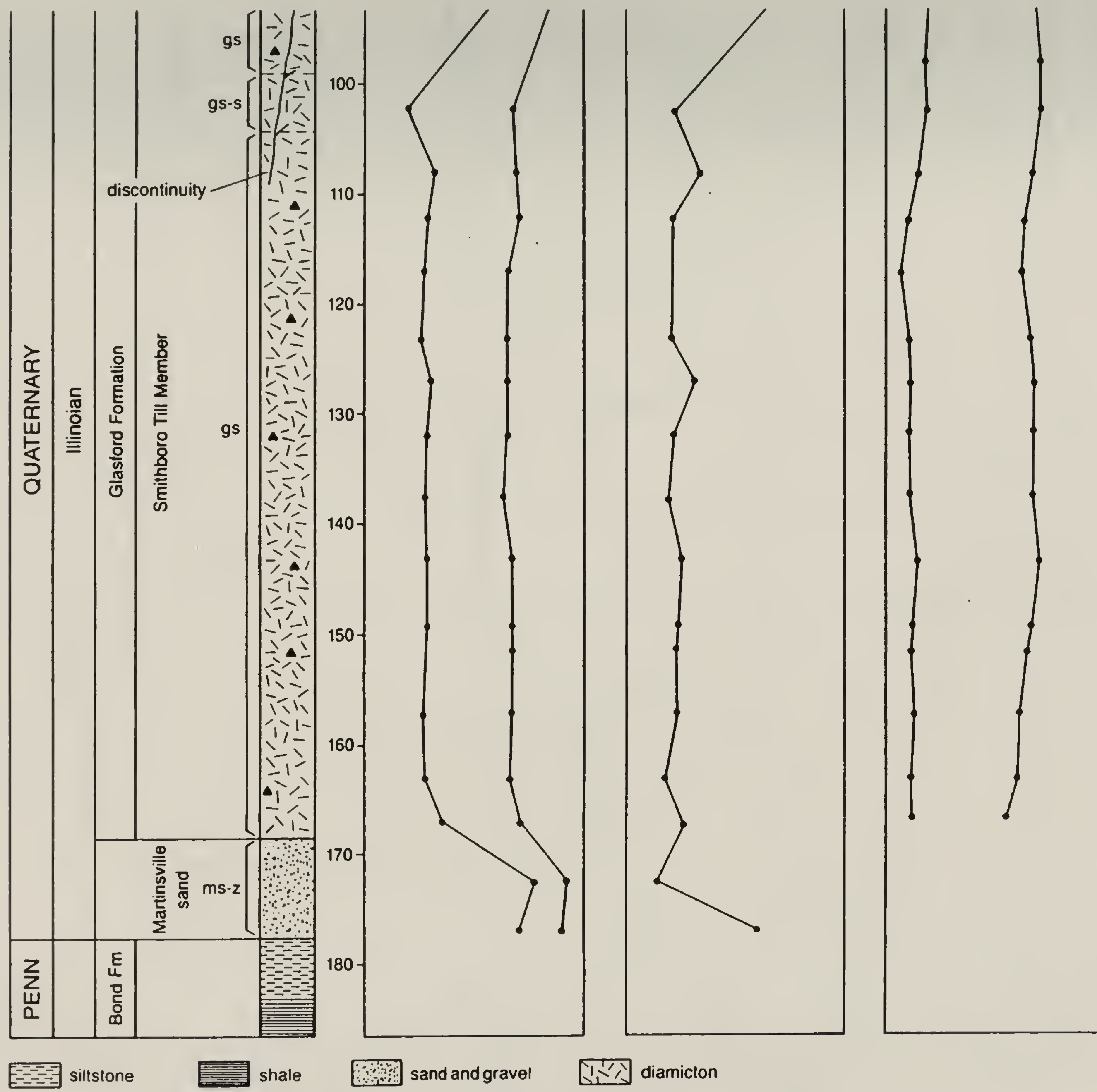
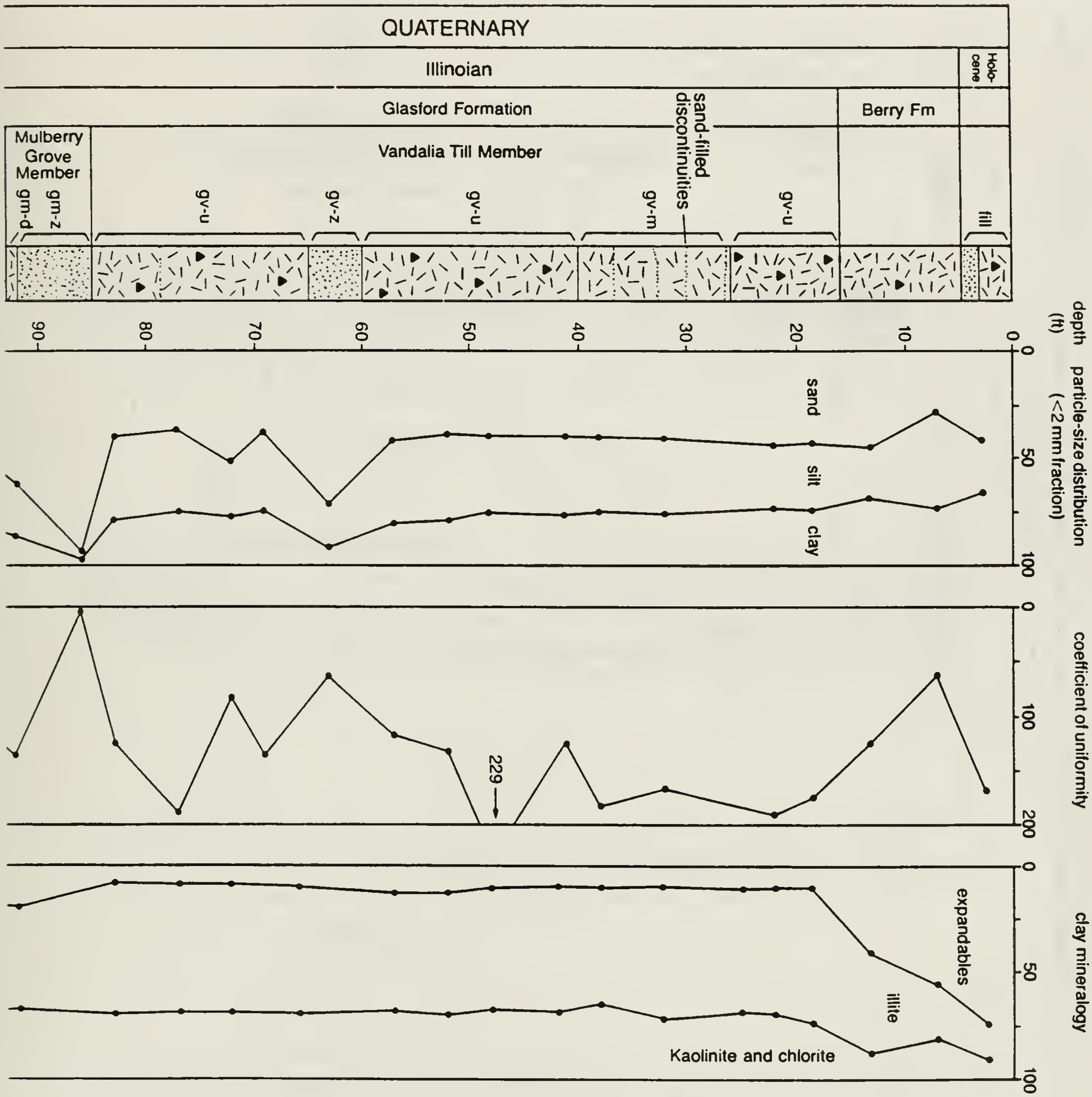


Figure 13 Lithofacies log and laboratory data from subsamples from core D-1. Triangles denote the relative abundance of >2 mm fragments per unit.


QUATERNARY
Illinoian
Holocene
Glasford Formation
Berry Fm
Mulberry Grove Member
Vandalia Till Member
sand-filled discontinuities
gm-d
gm-z
gv-u
gv-z
gv-u
gv-m
gv-u
fill
depth (ft)
particle-size distribution (<2 mm fraction)
sand
silt
clay
coefficient of uniformity
229
clay mineralogy
expandables
illite
Kaolinite and chlorite

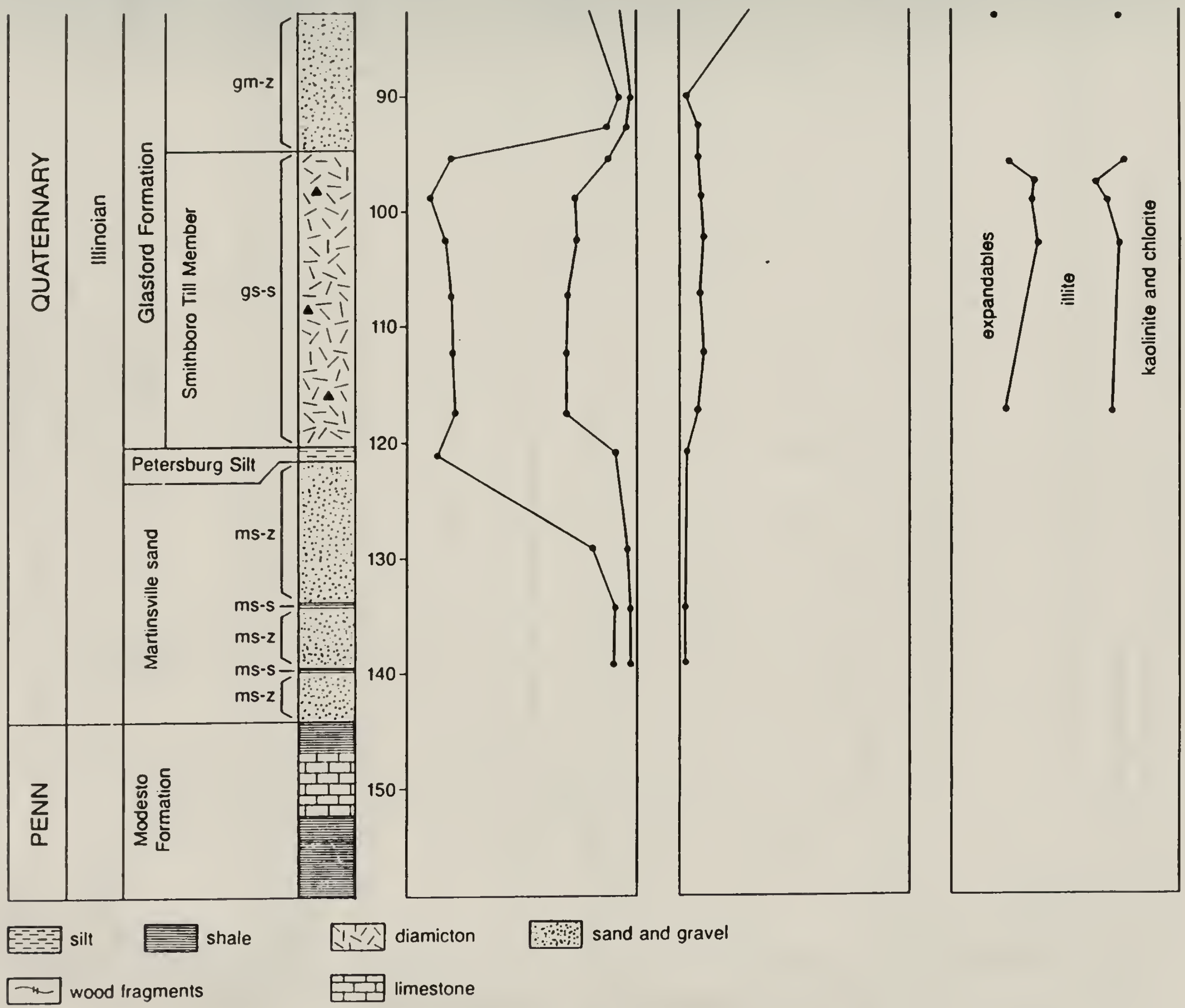
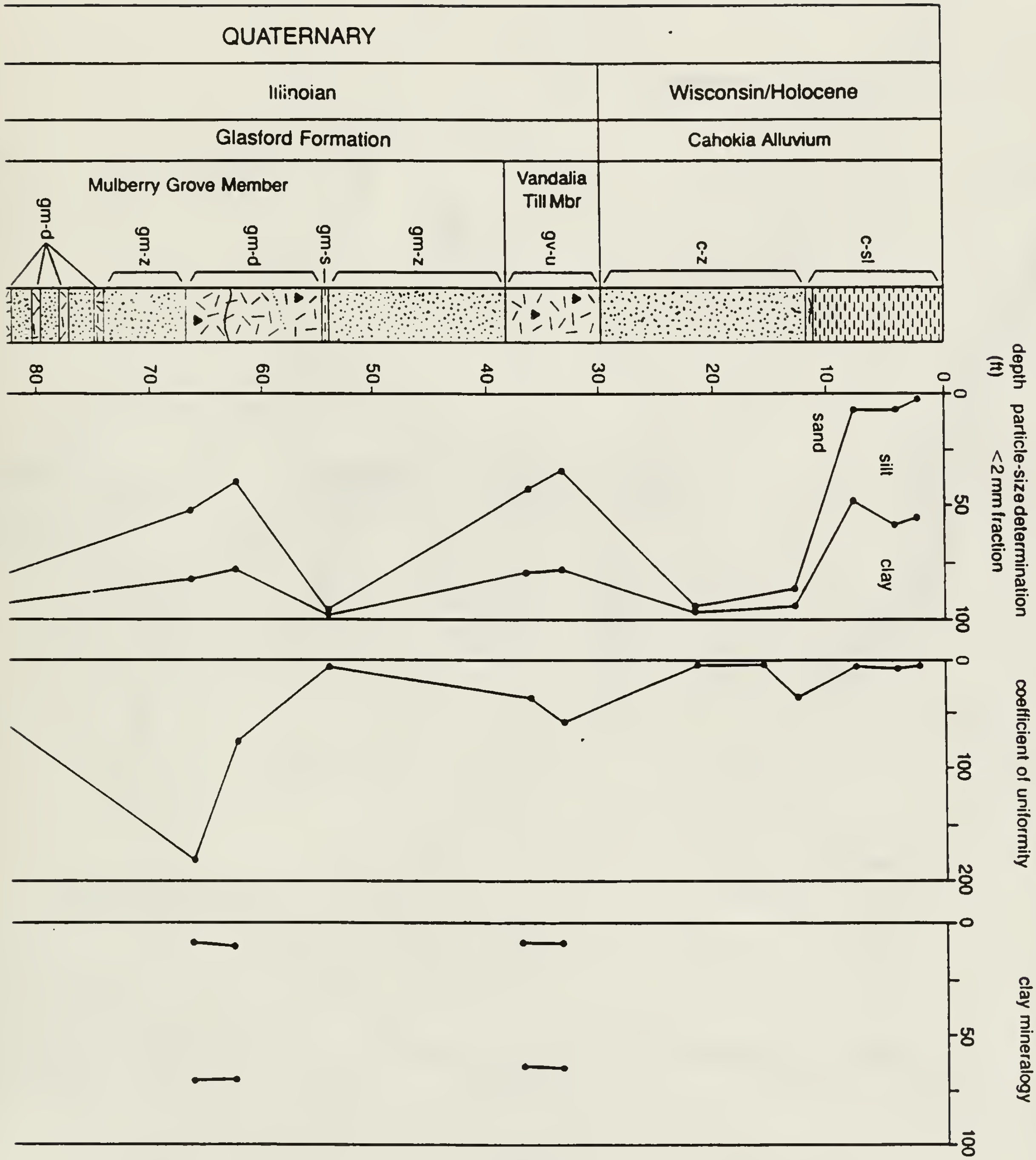
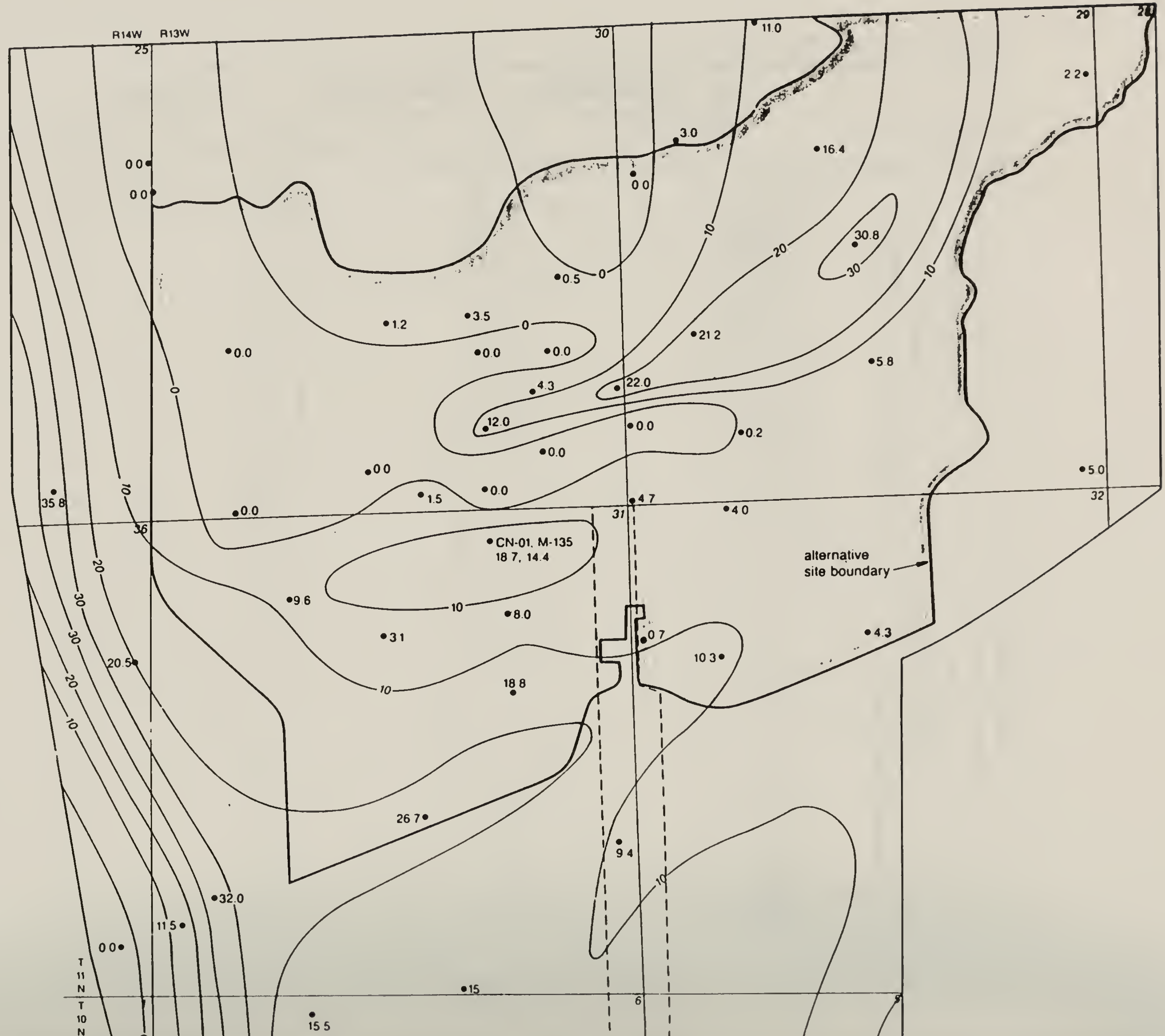


Figure 14 Lithofacies log and laboratory data from subsamples from core C-1. Triangles denote relative abundance of >2 mm fragments per unit.


QUATERNARY
Illinoian
Wisconsin/Holocene
Glasford Formation
Cahokia Alluvium
Mulberry Grove Member
Vandalia Till Mbr
gm-d
gm-z
gm-d
gm-s
gm-z
gv-u
c-z
c-sl
depth (ft)
particle-size determination <2 mm fraction
sand
silt
clay
coefficient of uniformity
clay mineralogy



R14W
R13W
alternative
site boundary
CN-01, M-135
18 7, 14.4
T
11
N
T
10
N

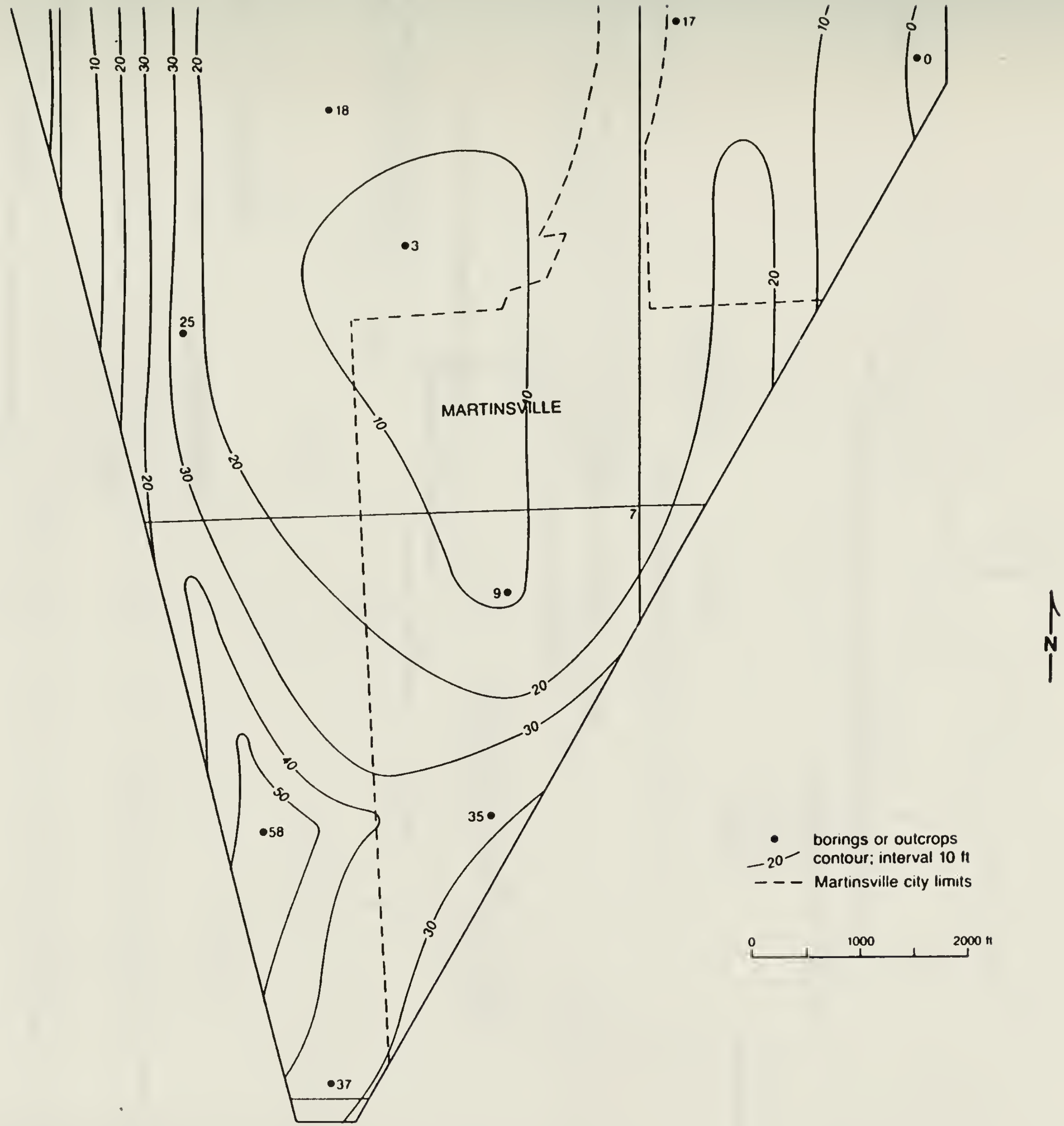
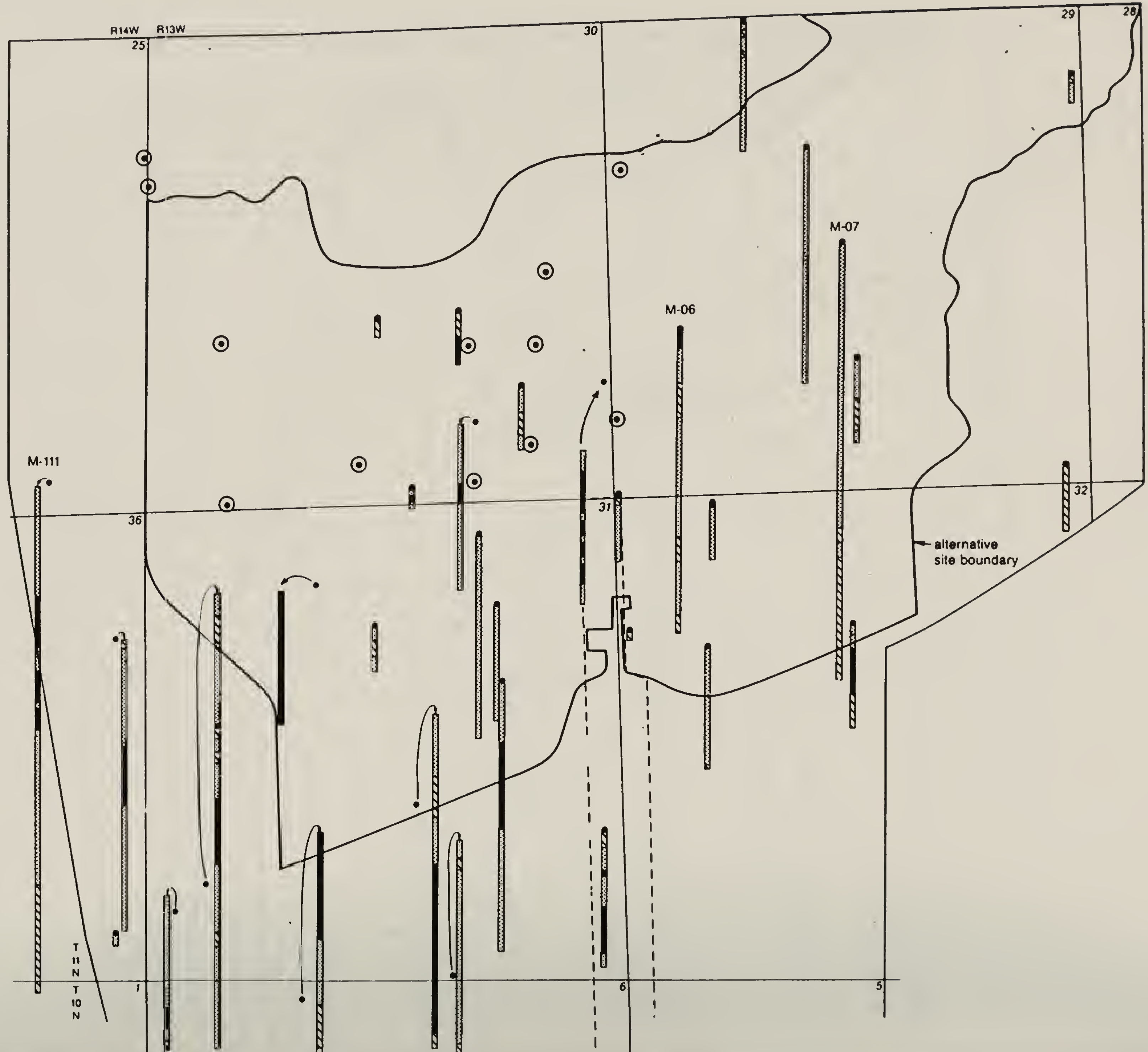


Figure 15 Thickness of the Mulberry Grove Member, Glasford Formation (modified from Curry et al., 1991).



R14W
R13W
25
30
29
28
32
31
36
1
6
5
M-07
M-06
M-111
alternative site boundary
T 11 N
T 10 N

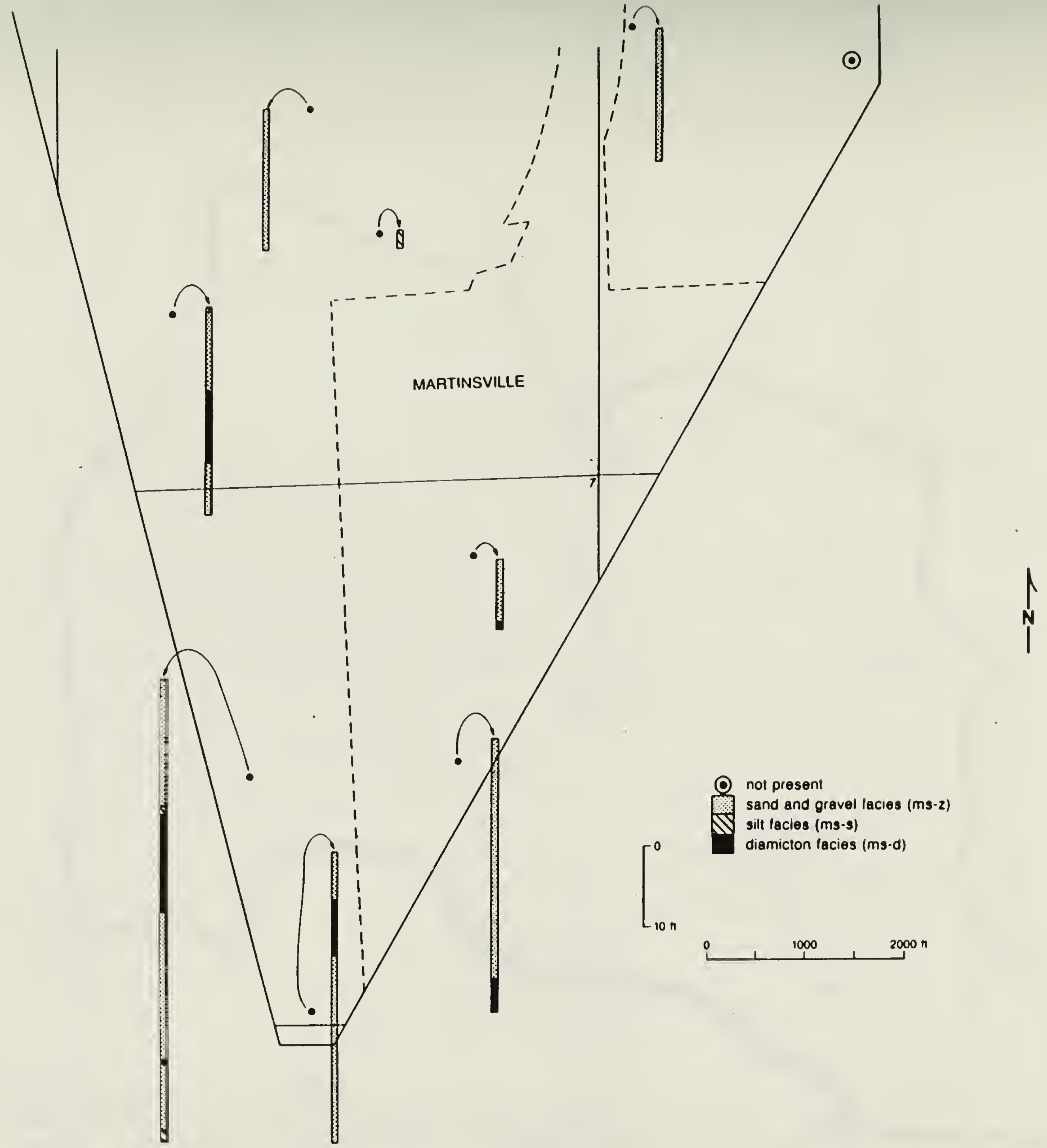
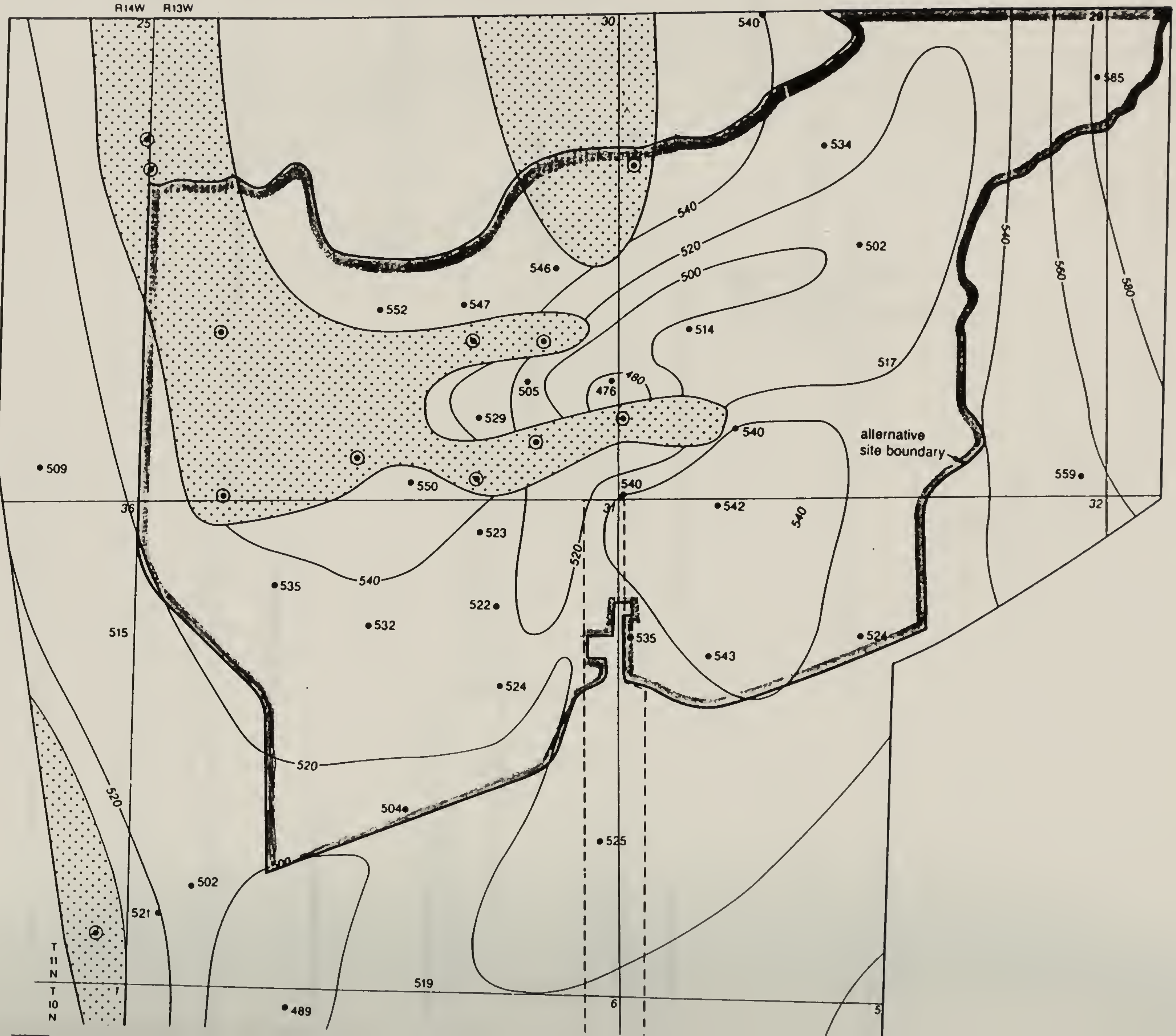


Figure 16 Thickness of lithofacies of Mulberry Grove Member (modified from Curry et al., 1991).


R14W
R13W
T 11 N
T 10 N
alternative site boundary

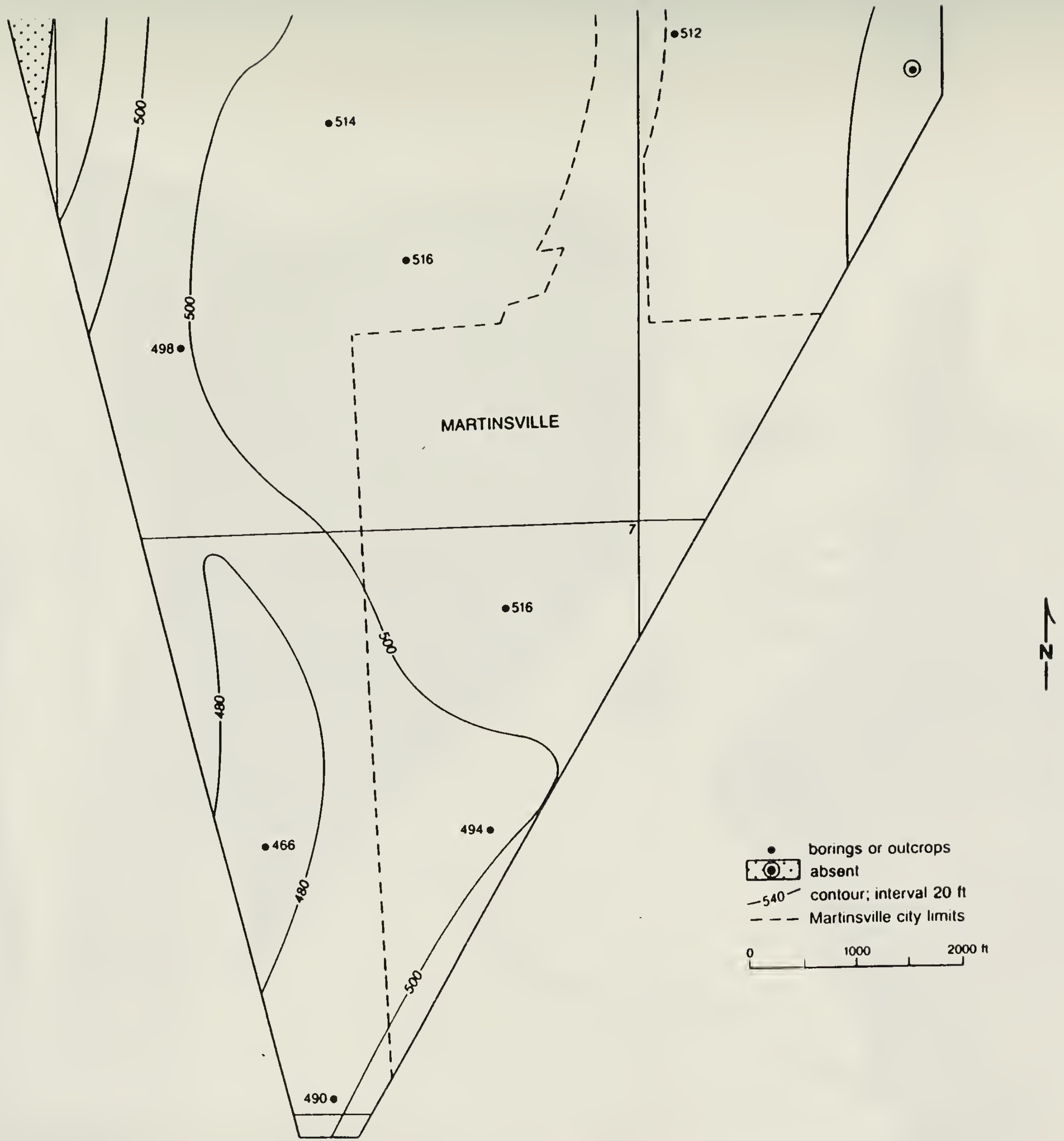
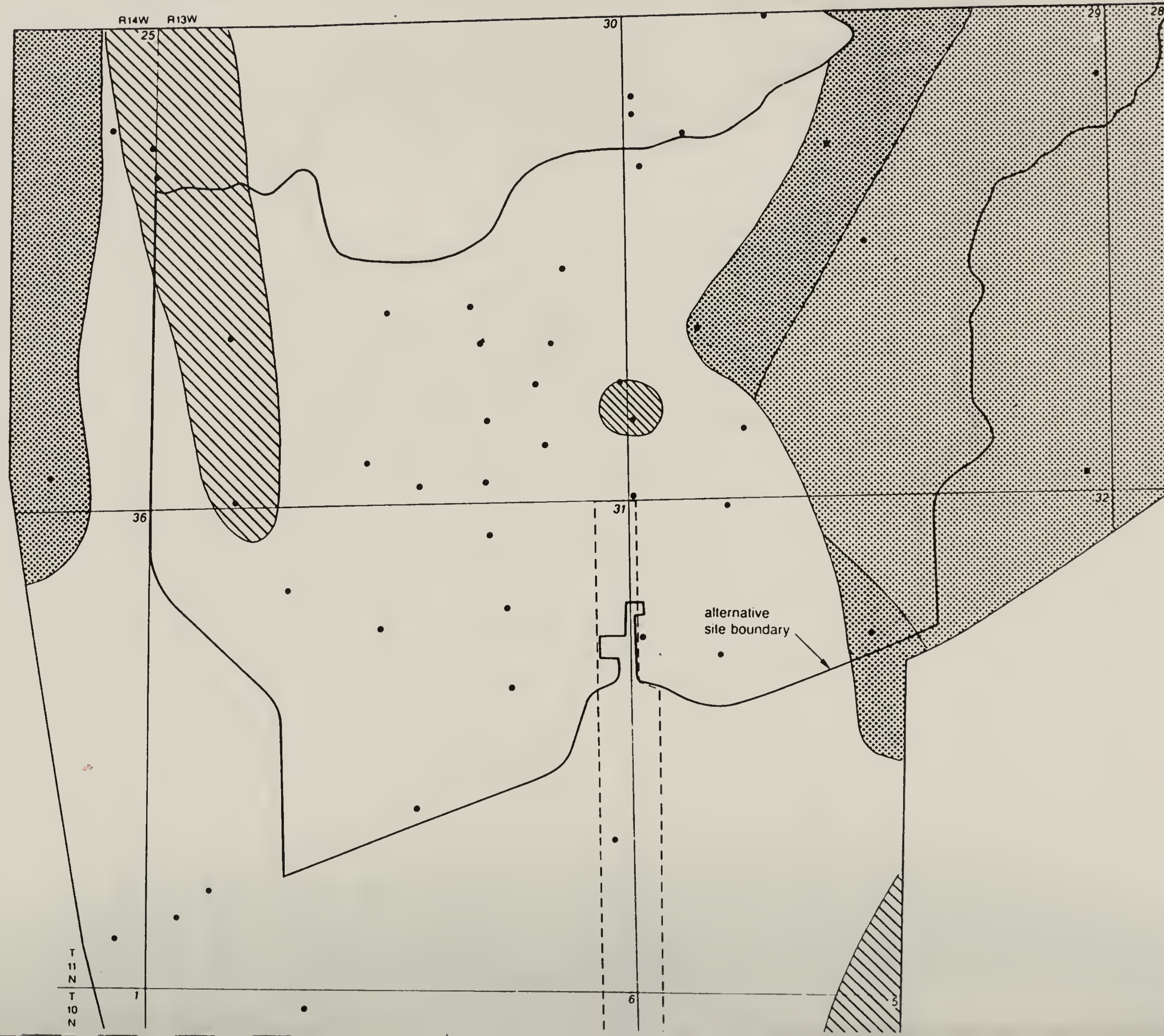


Figure 17 Elevation of the base of the Mulberry Grove Member, Glasford Formation (modified from Curry et al., 1991).


R14W
R13W
25
30
29
28
36
31
32
alternative
site boundary
T
11
N
T
10
N
1
6
5

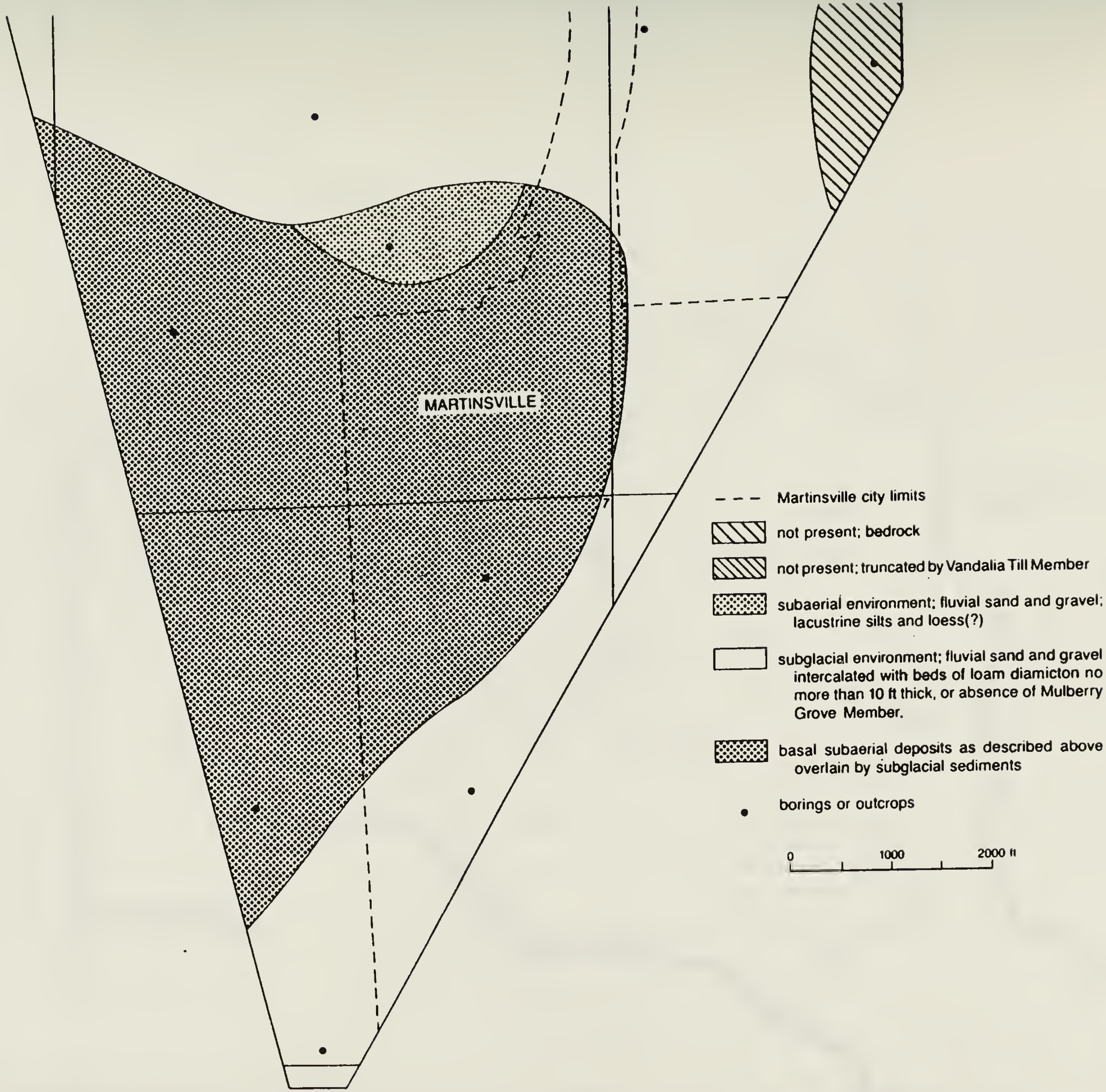


Figure 18 Interpreted environments of deposition of the Mulberry Grove Member, Glasford Formation.


R14W
R13W
25
30
29
36
31
32
1
6
5
T 11 N
T 10 N
alternative site boundary
570
550
530
510
490
587
557
551
561
543
533
547
553
551
564
548
535
535
523
509
498
474
541
540
515
551
545
552
549
549
545
546
564
537
544
530
536
535
536
554
528
543
531
534
534
532
525
534
505

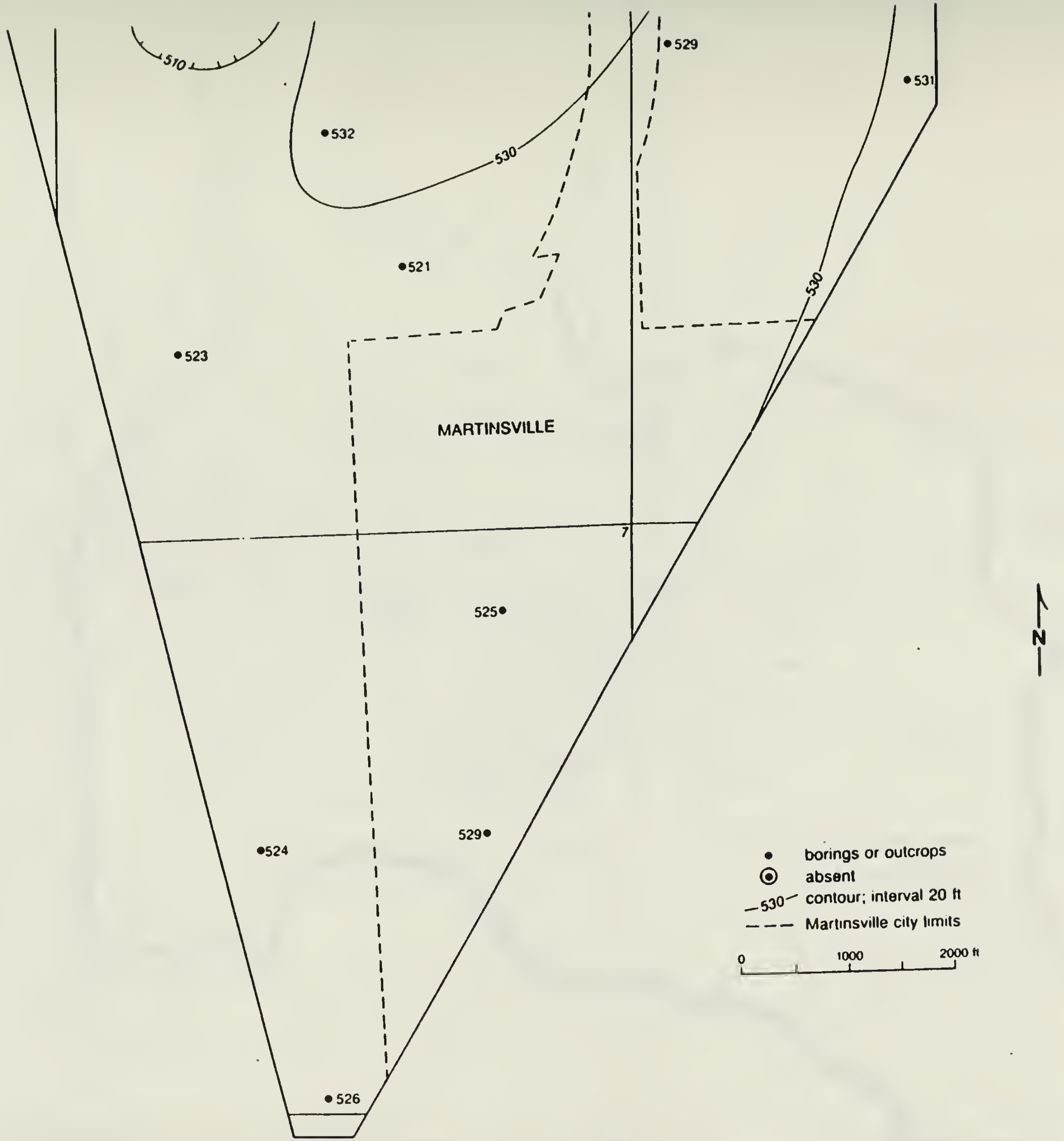
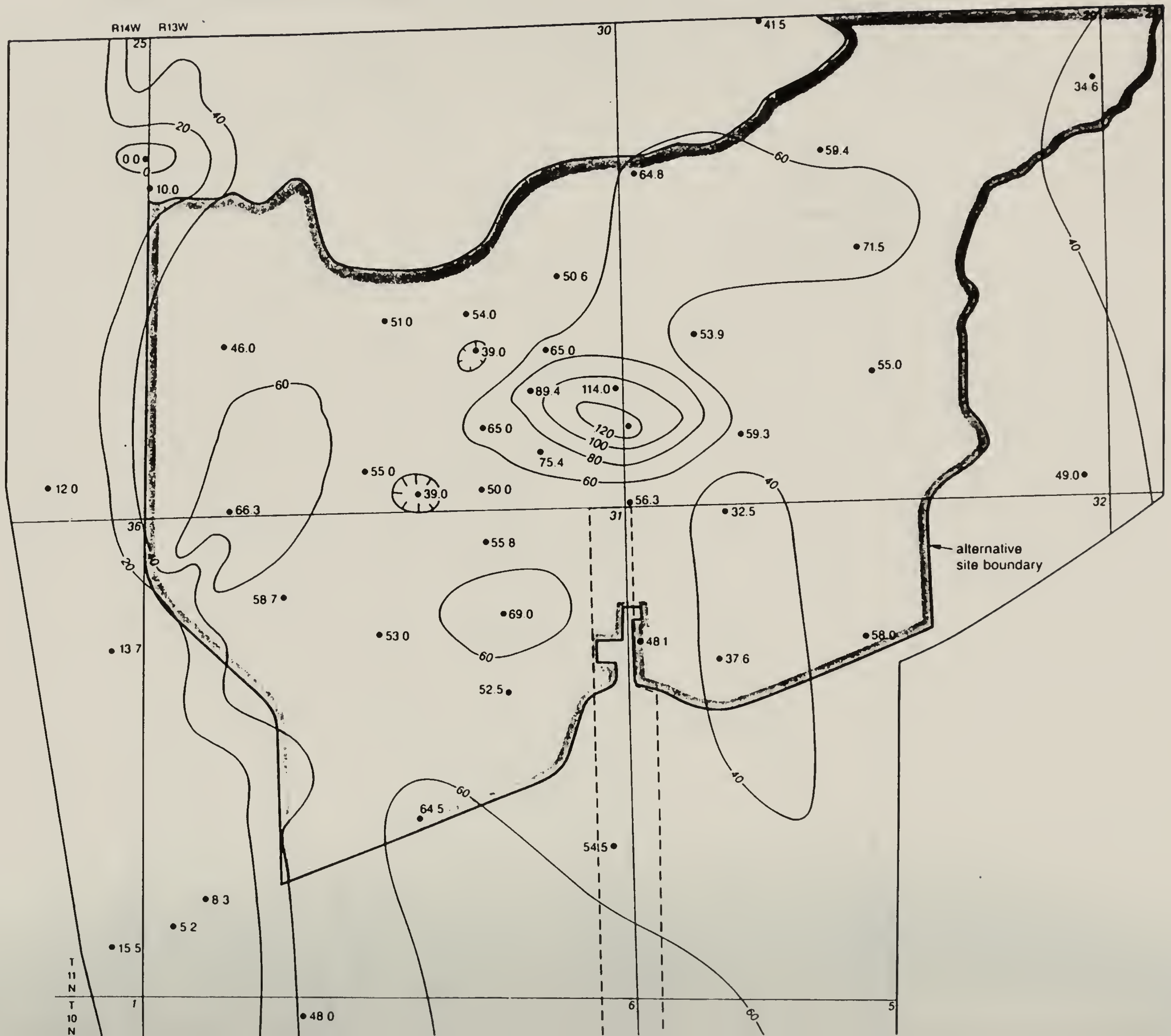


Figure 19 Elevation of the lower surface of the Vandalia Till Member, Glasford Formation, (modified from Curry et al., 1991).


R14W
R13W
alternative
site boundary
T
11
N
T
10
N

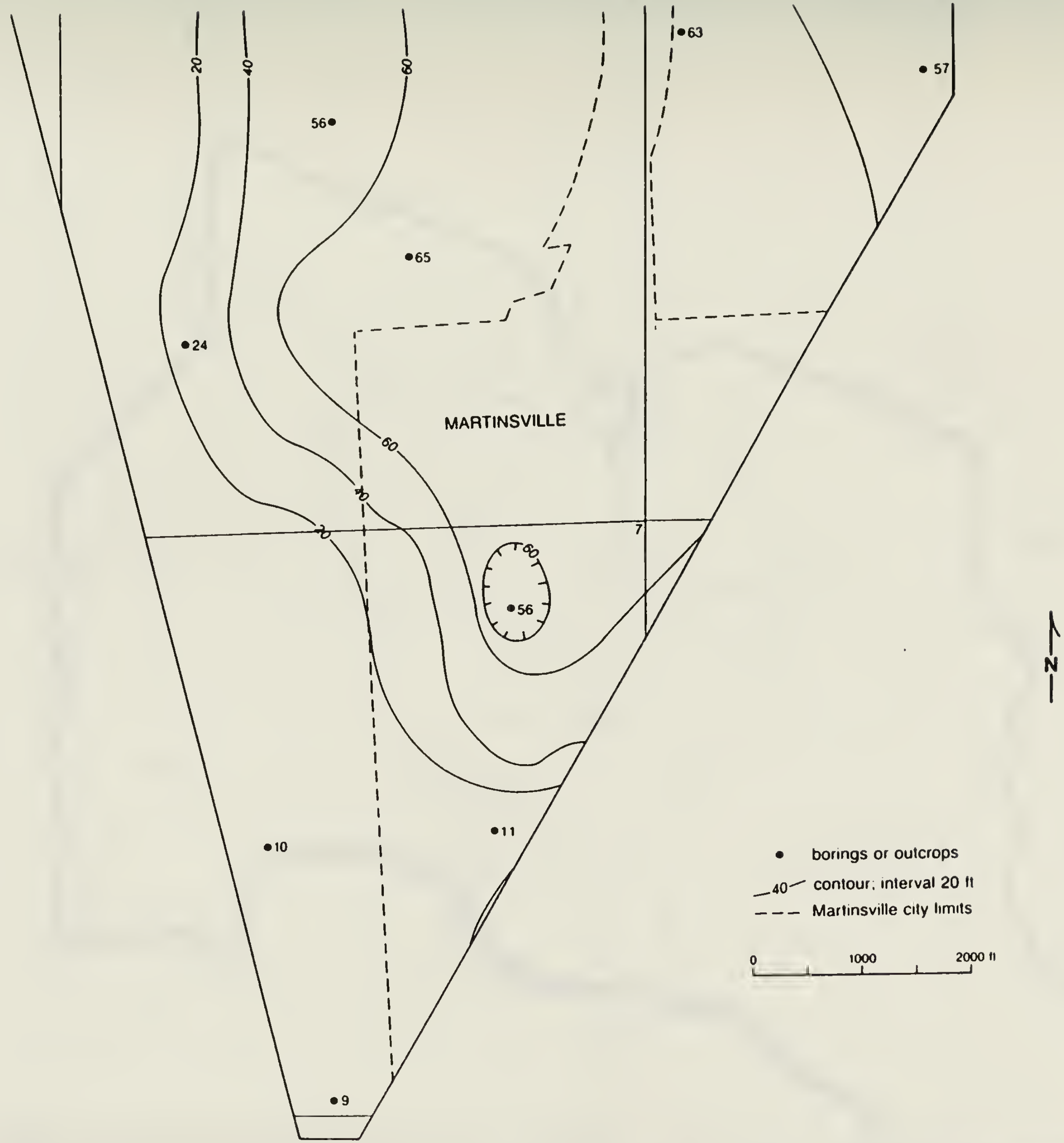
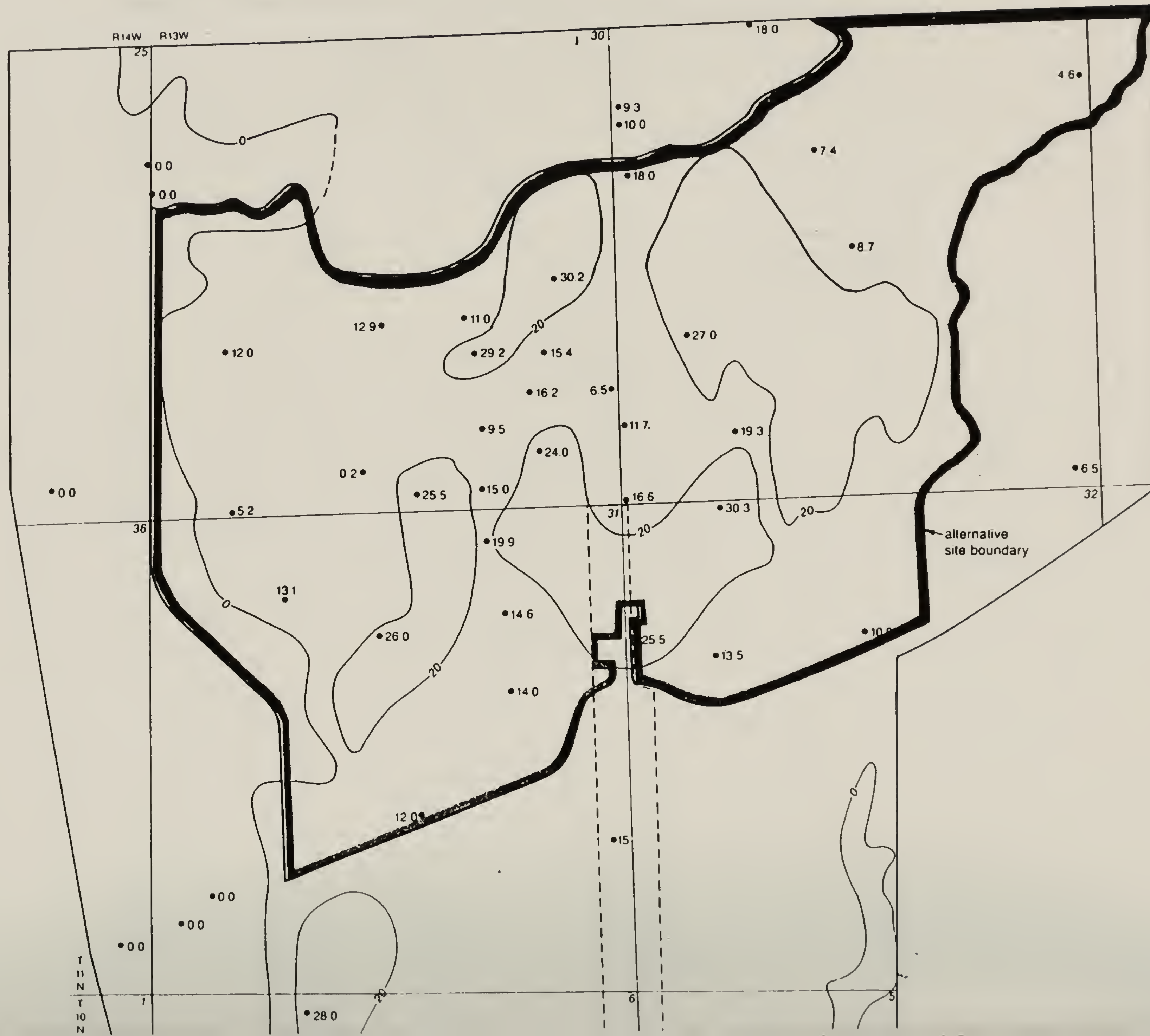


Figure 20 Thickness of the uniform diamicton facies of the Vandalia Till Member, Glasford Formation (modified from Curry et al., 1991).



R14W
R13W
25
30
32
36
31
1
6
5
T 11 N
T 10 N
alternative site boundary
0
20
18 0
4 6
9 3
10 0
7 4
0 0
0 0
18 0
8 7
30 2
11 0
12 9
20
12 0
29 2
15 4
27 0
16 2
6 5
9 5
11 7.
19 3
24.0
0 2
25 5
15 0
0 0
5 2
16 6
30 3
6 5
19 9
13 1
14 6
26 0
25 5
13 5
14 0
12 0
15
0 0
0 0
0 0
28 0

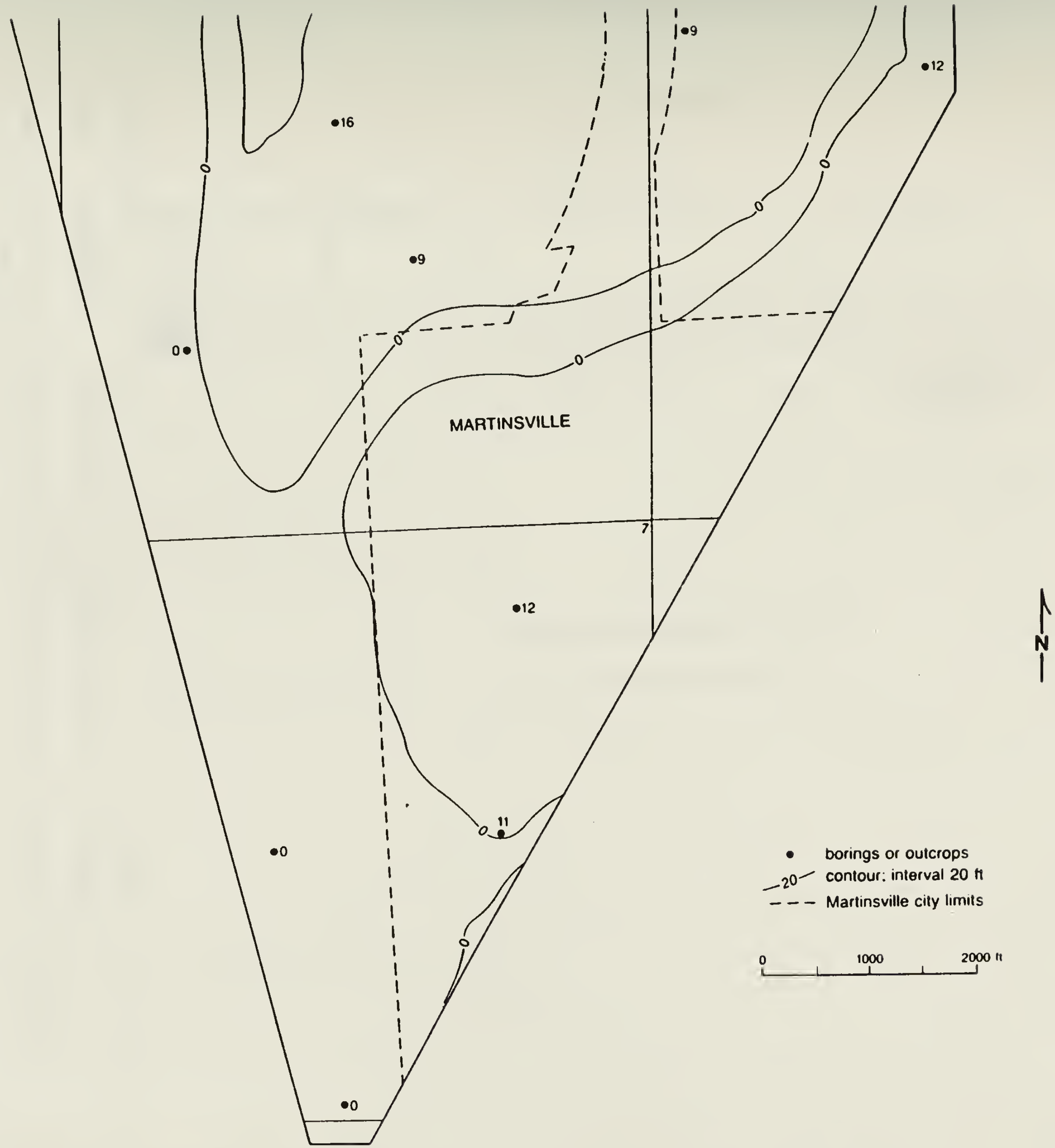


Figure 21 Thickness of the mélange facies of the Vandalia Till Member, Glasford Formation (modified from Curry et al., 1991).

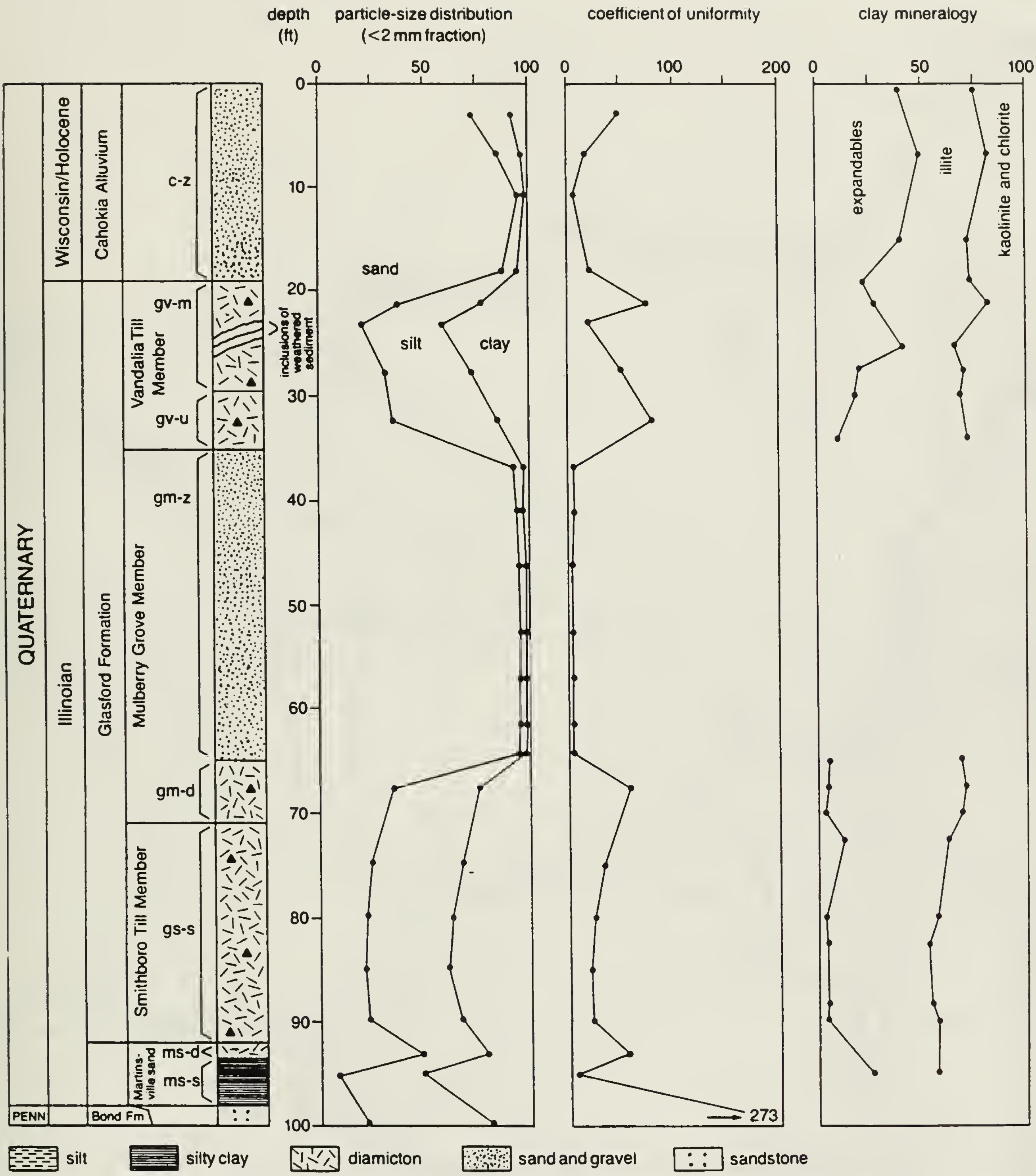
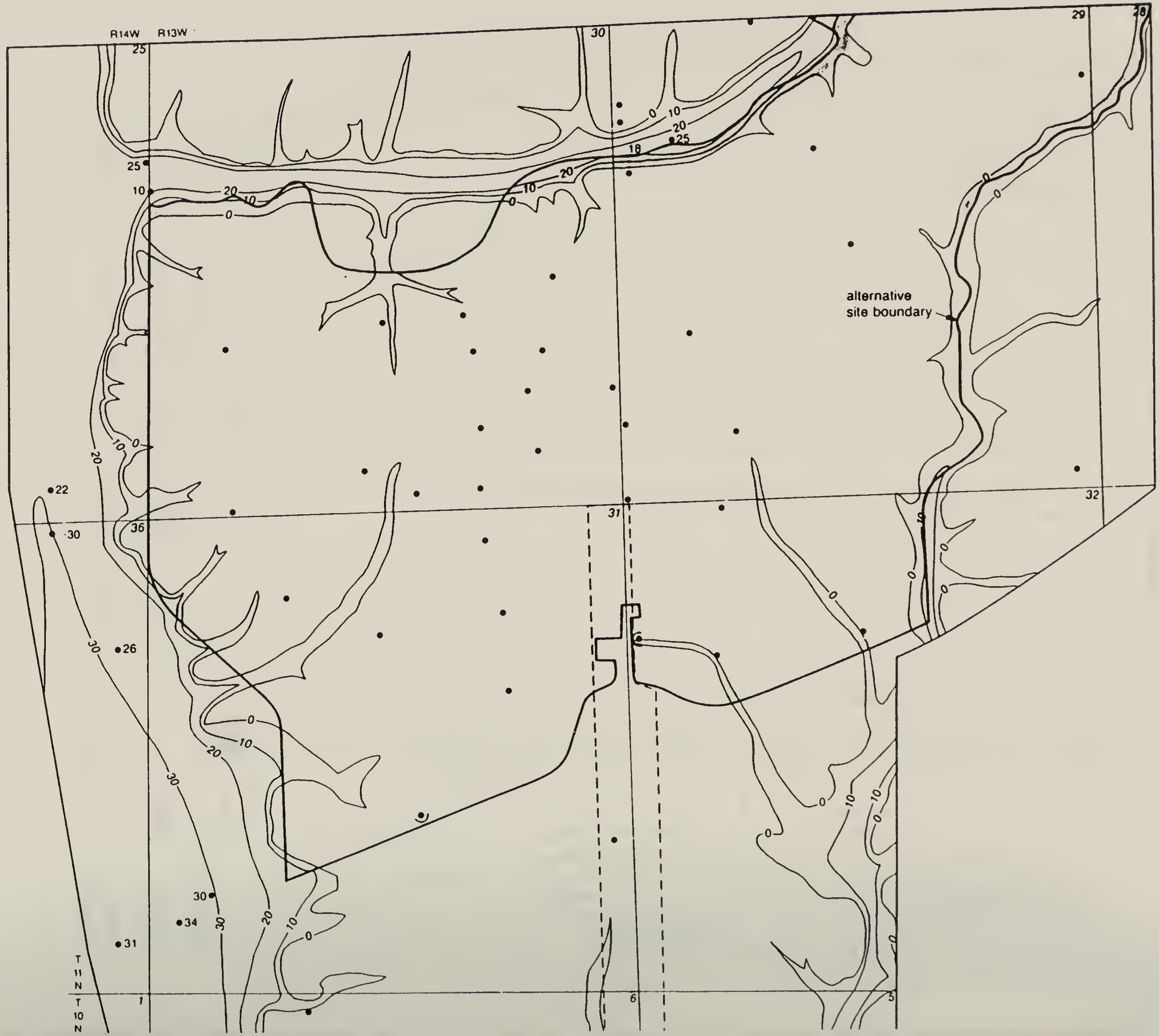


Figure 22 Lithofacies log and laboratory data from subsamples from core A-1. Triangles denote the relative abundance of >2 mm fragments per unit.


R14W
R13W
T 11 N
T 10 N
alternative site boundary

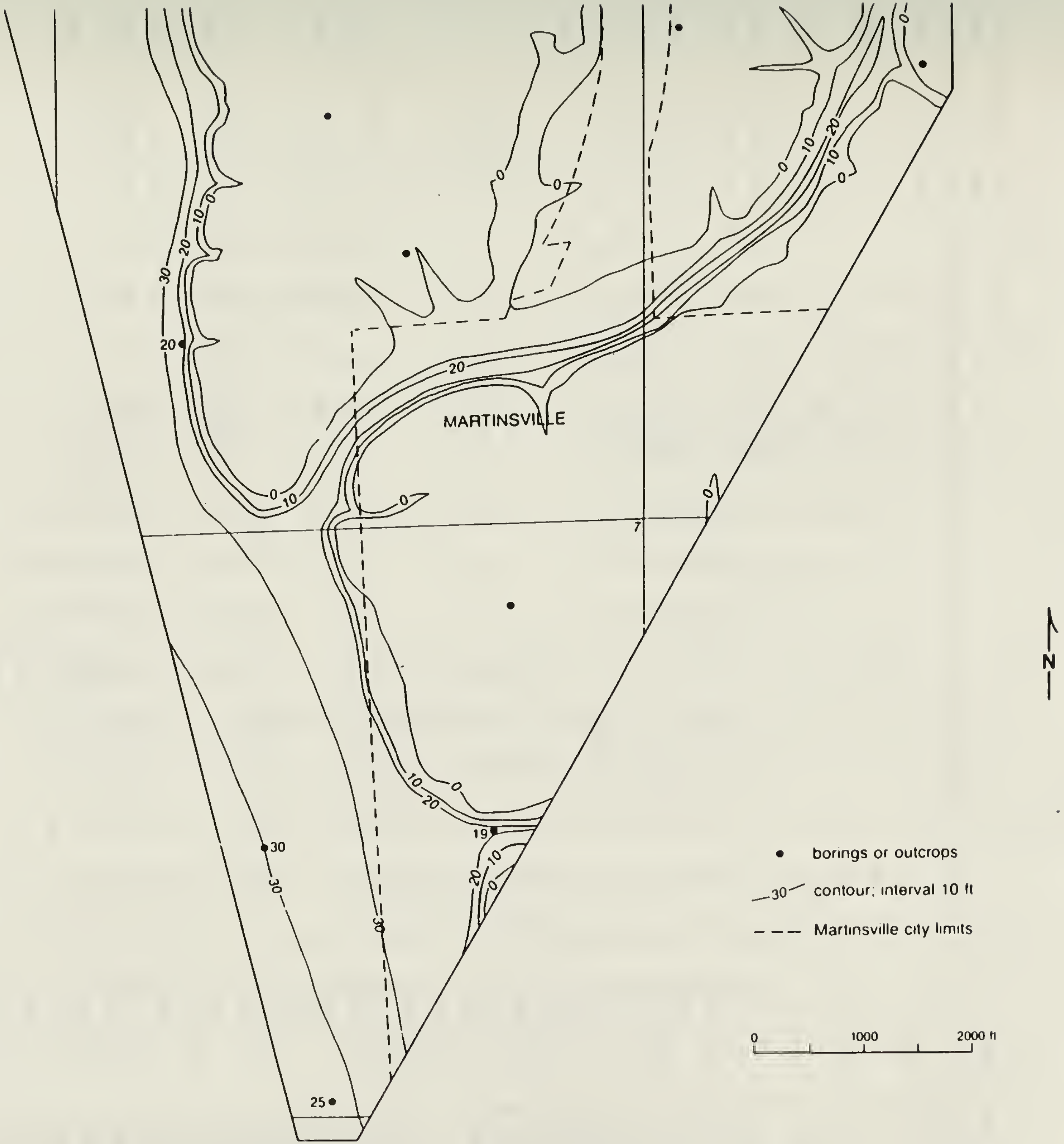


Figure 23 Thickness and distribution of Cahokia Alluvium.

BOREHOLE # A-1
ELEVATION: 564.4

SAMPLE IDENTIFICATION			PARTICLE SIZE DISTRIBUTION				ENGINEERING DATA					MINERALOGY OF THE <2um FRACTION								
			TOT		<2mm															
DEP TOP	DEP BOT	UNIT	GVL %	SD %	ST %	CL %	Cu	W%	LL	PL	PI	EXP %	ILL %	C-K %	CAL	DOL	VERM IND	DI	HSI	INT CPS
0.6		c										39	37	24	0	0	36>	1.0	1	1860
2.9	3.4	c	12	73	17	10	46.0	8.8												
6.8	7.3	c	0	85	11	4	16.3	19.9				50	32	18	0	0	46>	1.2	4	2080
10.7	11.2	c	4	95	3	2	2.9	19.5												
15.0		c										39	32	29	0	0	38>	0.7	2	2820
18.2	18.7	c	60	88	5	7	25.8	17.3												
19.6		gv-m										22	50	28	25	35	19>	1.2	2	2910
21.0	21.5	gv-m	18	38	40	22	151.8	11.6	21	13	8	28	41	31	40	38	23>	0.9	0	3320
23.0	23.5	gv-m	2	23	37	40	18.2	19.0	41	13	28									
25.5		gv-m										39	26	35	0	0	31>	0.5	1	2110
27.5	28.0	gv-m	10	31	40	29	54.3	12.6	26	12	14	19	51	30	48	42	11>	1.2	X	2305
29.8		gv-m										17	51	32	30	35	13>	1.1	X	2270
32.0	32.5	gv-u	18	36	46	18	80.7	11.4	22	14	8									
33.8		gv-u										11	61	28	33	30	1>	1.4	X	2320
36.5	37.0	gm-z	22	92	5	3	5.7	12.8												
41.0	41.5	gm-z	5	96	1	3	4.3	12.7												
46.0	46.5	gm-z	1	97	1	2	3.2	17.8												
52.5	53.0	gm-z	3	97	2	1	2.6	18.4												
57.0	57.5	gm-z	5	97	1	2	2.8	15.0												
61.5	62.0	gm-z	51	96	1	3	3.4	8.1												
64.0	64.5	gm-z	22	96	3	1	5.1	11.3				9	59	32	55	30	4>	1.2	X	2750
67.5	68.0	gm-d	8	35	41	24	59.3	10.4	20	12	8	7	64	29	60	29	1<	1.4	X	2790
69.9		gm-d										4	65	31	40	20	3<	1.4	X	1250
72.5		gs										13	49	38	42	20	6>	0.9	X	2370
74.5	75.0	gs-s	4	25	42	33	35.0	13.9	28	14	14									
79.5	80.0	gs-s	4	22	42	36	27.6	15.7	29	15	14	8	50	41	25	20	9>	0.8	X	2510
82.3		gs-s										8	45	47	30	20	10>	0.6	X	2350
84.5	85.0	gs-s	4	21	41	38	25.1	16.0	30	16	14									
87.8		gs-s										9	46	45	25	20	12>	0.6	X	2270
89.5	90.0	gs-s	1	23	44	33	23.0	15.6	28	15	13	8	49	43	35	15	13>	0.8	X	1460
93.0	93.5	ms-d	12	48	36	16	58.7	20.4	30	23	7									
95.0	95.5	ms-s	2	8	41	51	9.1	18.4	42	14	28	26	31	43	40	28	28>	0.5	X	2320
99.0	99.5	Plm-x	28	47	33	20	272.6	18.9	36	23	13									
103.0	103.5	Plm-x						8.5												
106.0	106.5	Plm-x						16.6												

BOREHOLE # B-1
ELEVATION: 601.0

SAMPLE IDENTIFICATION			PARTICLE SIZE DISTRIBUTION				ENGINEERING DATA					MINERALOGY OF THE <2um FRACTION								
DEP TOP	DEP BOT	UNIT	TOT GVL %	SD %	<2mm ST %	CL %	Cu	W%	LL	PL	PI	EXP %	ILL %	C-K %	CAL	DOL	VERM IND	DI	HSI	INT CPS
2.4	2.4	r										56	27	17	0	0	32>	1.0	9	1560
2.5	3.0	b	3	43	19	38	122.2	19.0	39	13	26									
5.5	6.0	b	3	41	21	38	121.5	18.6	36	14	22									
9.0	9.5	gv-mo	9	42	31	27	130.4	8.8	22	11	11	37	51	12	38	25	22>	2.8	5	1870
12.0	12.5	gv-mo	16	50	35	15	124.2	6.1	16	13	3	17	60	23	55	43	12>	1.7	1	1810
16.0	16.5	gv-m	6	43	29	28	126.3	7.2	23	11	12									
22.0	22.5	gv-u	5	44	33	23	124.1	6.9	20	11	9	8	61	31	65	45	4>	1.3	X	2160
27.5	28.0	gv-u	5	42	28	30	101.4	10.9	22	11	11	10	59	31	67	38	2>	1.3	X	2540
32.0	32.5	gv-u	9	40	33	27	127.7	10.4	24	12	12	13	55	32	45	30	6>	1.1	X	2180
38.5	39.0	gv-u	18	51	27	22	152.2	8.8	19	10	9	7	65	28	75	50	5<	1.6	X	2315
44.0	44.5	gv-u	17	40	38	22	138.7	9.8	21	12	9	9	60	31	38	36	3>	1.3	X	2110
48.5	49.0	gv-u	15	41	33	26	148.8	9.8	22	12	10	10	57	33	55	37	4>	1.1	X	2100
59.0	59.5	gv-u	12	43	36	21	131.4	12.1	22	12	10	10	60	30	33	25	5>	1.3	X	1750
65.0		gv-u										9	58	32	31	28	5>	1.2	X	1630
67.7		gv-u										7	61	32	44	49	3<	1.3	X	2560
70.3	70.8	gv-u	15	33	44	23	107.5	10.3	21	12	9	10	61	29	51	66	2>	1.4	X	2540
78.5	79.0	gv-u	15	39	41	20	93.0	9.6	20	13	7	11	60	29	48	35	1>	1.4	X	2540
80.5	81.0	gs	10	34	48	18	53.6	12.5	18	14	4									
81.1		gv-u										10	63	27	33	42	2>	1.5	X	2250
83.2		gm-s										10	62	28	43	50	1<	1.5	X	2420
86.0	86.5	gs	10	28	50	22	47.9	12.1	24	14	10	29	46	25	35	37	20>	1.2	0	3550
86.6		gs										29	45	26	37	30	22>	1.1	X	2670
88.2	88.7	gs	9	28	37	35	31.4	12.6	29	13	16	29	43	28	40	32	20>	1.0	?	2700
90.3		gs										24	48	28	50	22	17>	1.1	0	2330
93.5	94.0	gs	5	30	36	34	35.6	14.1	31	13	18	15	47	38	55	32	21>	1.2	0	2630
97.0	97.5	gs	2	26	38	36	23.1	14.3	33	13	20	20	49	31	30	20	19>	1.1	3	2850
100.0	100.5	gs-s	5	24	42	34	28.0	14.7	35	13	22									
101.1		gs-s										21	41	38	30	32	17>	0.7	0	2360
102.8		gs-s										20	40	40	41	32	25>	0.7	0	2980
104.5	105.0	bl	0	27	49	24	28.8	18.5	33	13	20	43	26	31	38	25	35>	0.5	4	2930
105.5	106.0	bl	0	13	45	42	16.3	19.5	40	14	26	42	29	29	20	20	34>	0.7	2	2370

BOREHOLE # C-1

ELEVATION: 562.0

SAMPLE IDENTIFICATION			PARTICLE SIZE DISTRIBUTION				ENGINEERING DATA					MINERALOGY OF THE <2um FRACTION								
DEP TOP	DEP BOT	UNIT	TOT GVL %	SD %	<2mm ST %	CL %	Cu	W%	LL	PL	PI	EXP %	ILL %	C-K %	CAL	DOL	VERM IND	DI	HSI	INT CPS
1.0	1.5	c	0	2	53	45	6.9	29.1	46	22	24									
3.5	4.0	c	0	7	50	43	8.6	26.9	41	14	27									
7.0	7.5	c	0	7	41	52	6.5	25.8	51	14	37									
12.6	13.1	c	13	87	8	5	35.5	15.4												
15.0	15.5	c	0	96	2	2	2.0	24.6												
21.5	22.0	c	5	96	2	2	3.0	17.5												
33.0	33.5	gv-u	7	34	44	22	59.9	10.0	22	12	10	11	55	34	30	25	7>	1.1	X	2030
36.5	37.0	gv-u	6	42	37	21	39.0	10.5	22	13	9									
37.1		gv-u										12	53	35	30	35	10>	1	X	2490
54.0	54.5	gm-z	0	97	1	2	2.2	22.7												
62.0	62.5	gm-d	11	40	37	23	75.0	10.2	20	12	8	11	59	30	40	45	2>	1.3	X	3140
66.0	66.5	gm-d	22	51	31	18	178.2	10.1				8	63	29	64	52	2<	1.4	X	2100
82.3		gm-d										18	55	27	40	30	11>	1.4	X	2460
90.0	90.5	gm-z	0	92	6	2	5.0	21.7												
92.0	92.5	gm-z	77	87	9	4	16.7	7.3												
95.5	96.0	gs-s	2	19	69	12	16.7	13.8				26	50	24	40	35	19>	1.4	2	2410
97.2		gs-s										37	37	36	32	25	27>	0.9	2	2860
98.5	99.0	gs-s	2	9	63	28	17.7	18.2	30	16	14	36	34	30	25	25	30>	0.7	X	2500
102.0	102.5	gs-s	5	17	57	26	19.4	18.2	31	15	16	37	38	25	35	37	28>	1.0	0	1755
107.0	107.5	gs-s	2	19	50	31	18.3	19.4	30	14	16									
112.0	112.5	gs-s	3	19	50	31	19.5	20.2	30	15	15									
117.0	117.5	gs-s	4	20	49	31	16.9	20.1	30	15	15	25	46	29	35	20	17>	1.0	2	1430
120.8	121.3	ps	0	12	78	10	7.0	22.7												
129.0	129.5	ms-z	0	79	17	4	8.9	18.7												
134.1	134.6	ms-z	1	91	6	3	4.4	17.8												
139.0	139.5	ms-z	2	91	6	3	6.1	15.8												
145.3		Pb										4	59	37	0	0	8<	1.1	X	6410

BOREHOLE # C-2

ELEVATION: 562.1

SAMPLE IDENTIFICATION			PARTICLE SIZE DISTRIBUTION				ENGINEERING DATA					MINERALOGY OF THE <2um FRACTION								
			TOT		<2mm															
DEP TOP	DEP BOT	UNIT	GVL %	SD %	ST %	CL %	Cu	W%	LL	PL	PI	EXP %	ILL %	C-K %	CAL	DOL	VERM IND	DI	HSI	INT CPS
64.5	65.0	gm-d	8	50	32	18	119.9	10.1				9	66	25	45	48	1<	1.8	X	3440
67.0	67.5	gm-z	20	81	11	8	50.6	12.1												
69.5	70.0	gm-z	28	85	12	3	19.9	11.7												
71.7	72.2	gm-z	42	84	12	4	22.5	14.1												
75.0	75.5	gm-d	6	32	46	22	49.6	12.9	21	13	8	23	51	26	35	30	17>	1.3	X	2470
77.4	77.9	gm-d	10	44	40	16	114.0	14.6	16	13	3									
80.0	80.5	gm-d	20	37	44	19	114.5	12.7	21	13	8	19	53	28	40	36	12>	1.3	X	2360
82.2	82.7	gm-d	12	57	32	11	59.5	13.9												
84.6	85.1	gm-z	20	79	16	5	47.0	10.8												
86.8	87.3	gm-z	16	88	7	5	14.2	16.2												
89.3	89.8	gm-z	9	63	26	11	52.6	14.8												
91.3	91.8	gs	6	29	48	23	42.3	11.7												
94.4	94.9	gs	8	29	47	24		15.3				36	39	25	17	20	30>	1.0	2	3110
120.0	120.5	gs-s	4	20	49	31	19.5	18.5	30	14	16	30	35	35	30	25	29>	0.7	X	1450
122.5	123.0	gs-s	2	19	64	17	21.0	21.1												
125.0	125.5	ms-z	13	75	17	8	22.0	17.6												
127.0	127.5	ms-z	8	87	10	3	8.9	21.7												
129.5	130.0	ms-z	47	89	7	4	6.1	13.1												
131.7	132.2	ms-z	59	90	5	5	5.9	13.9												
133.9	134.4	ms-z	73	74	26	0	10.0	10.4												
139.2	139.7	ms-z	14	79	14	7	15.1	6.9												

BOREHOLE # D-1
ELEVATION: 610.1

SAMPLE IDENTIFICATION			PARTICLE SIZE DISTRIBUTION				ENGINEERING DATA					MINERALOGY OF THE <2um FRACTION								
			TOT	<2mm																
DEP TOP	DEP BOT	UNIT	GVL %	SD %	ST %	CL %	Cu	W%	LL	PL	PI	EXP %	ILL %	C-K %	CAL	DOL	VERM IND	DI	HSI	INT CPS
2.5	3.0	fill	13	43	23	34	169.8	19.1	36	11	25	75	16	9	0	0	38>	1.1	15	2870
7.0	7.5	b	16	29	44	27	61.4	20.7	27	12	15	56	25	19	0	0	44>	0.9	8	1670
13.5	14.0	b	5	45	23	32	125.2	20.6	28	11	17	42	45	13	0	0	38>	2.2	4	2560
18.0	18.5	gv-u	18	43	32	25	173.8	8.4	19	10	9	10	63	27	72	45	2>	1.5	X	2290
22.0	22.5	gv-u	20	44	29	27	191.3	9.5	20	11	9	9	60	31	68	50	1<	1.3	X	2500
25.9		gv-m										11	57	32	62	35	4>	1.2	X	2700
32.5	33.0	gv-m	20	41	35	24	167.4	10.4	19	11	8	10	62	28	77	53	2<	1.5	X	2960
38.0	38.5	gv-m	22	40	35	25	183.8	10.6	22	12	10	10	55	35	62	37	4>	1.0	X	2860
41.0	41.5	gv-u	16	39	37	24	123.7	10.7	22	12	10									
42.2		gv-u										10	58	32	58	33	8>	1.2	X	2140
48.0	48.5	gv-u	25	40	35	25	229.0	9.8	22	18	7	11	56	33	45	25	7>	1.2	X	2230
52.0	52.5	gv-u	18	39	40	21	132.0	9.1	21	12	9	14	57	29	50	42	6>	1.3	X	1730
57.0	57.5	gv-u	12	41	39	20	118.6	10.4	22	12	10	13	55	32	42	28	6>	1.1	X	1970
63.5	64.0	gv-z	25	71	20	9	65.7	12.0												
66.3		gv-u										11	59	30	50	42	2>	1.3	X	2350
69.0	69.5	gv-u	20	38	37	25	138.9	10.4	20	13	7									
72.0	72.5	gv-u	11	52	26	22	86.1	10.5	21	12	9	9	61	30	40	28	1>	1.4	X	2620
77.0	77.5	gv-u	20	38	37	25	190.7	10.3	21	12	9	8	62	30	56	42	2>	1.4	X	2480
83.0	83.5	gv-u	13	40	39	21	127.1	10.9	21	12	9	8	63	29	35	43	0	1.4	X	2470
86.0	86.5	gm-z	0	94	4	2	2.4	21.3												
92.5	93.0	gm-d	27	62	24	14	135.6	18.4												
93.0		gm-s										21	47	32	40	22	11>	1.0	3	1420
97.9		gs										18	54	28	45	25	11>	1.3	X	2220
102.0	102.5	gs-s	10	20	48	32	44.5	10.1	26	13	13	19	53	28	50	25	12>	1.3	0	1970
108.0	108.5	gs	10	33	38	29	65.1	10.8	22	13	9	15	53	32	43	20	9>	1.1	X	2560
112.0	112.5	gs	9	29	38	33	39.9	12.8	25	13	12	8	55	37	43	30	5>	1.0	X	2500
117.0	117.5	gs	10	28	38	34	39.7	13.7	27	13	14	7	55	38	45	20	8>	1.0	X	2870
123.0	123.5	gs	11	27	39	34	39.0	13.7	26	13	13	11	55	34	56	23	10>	1.1	X	2990
127.1	127.5	gs	13	31	35	34	61.7	13.7	26	14	12	11	57	32	50	30	7>	1.2	X	3020
132.0	132.5	gs	8	28	38	34	42.4	13.7	26	13	13	11	56	33	35	33	9>	1.1	X	2360
137.5	138.0	gs	10	28	37	35	38.2	12.5	26	12	14	12	56	32	40	29	5>	1.2	X	2090
143.0	143.5	gs	11	30	37	33	50.2	14.3	26	13	13	14	56	30	52	25	4>	1.2	X	2295
149.0	149.5	gs	10	29	38	33	48.4	13.9	26	13	13	12	54	34	43	34	6>	1.1	X	2320
151.0	151.5	gs	10	29	40	31	47.0	14.9	27	12	15	12	52	36	40	30	7>	1.0	X	2230
157.0	157.5	gs	13	27	40	33	46.9	15.8	28	13	15	13	47	40	50	30	9>	0.8	X	2270
163.0	163.5	gs	11	28	39	33	36.0	17.8	27	14	13	11	47	42	35	27	11>	0.8	X	2090
167.0	167.5	gs	3	36	36	28	49.7	14.2	25	13	12	12	43	45	33	32	15>	0.6	X	1200
172.5	173.0	ms-z	2	79	13	8	28.5	24.1				22	50	28	17	10	12>	1.2	5	685
177.0	177.5	ms-z	29	71	18	11	118.1	18.6												

BOREHOLE # E-1
ELEVATION: 576.9

SAMPLE IDENTIFICATION			PARTICLE SIZE DISTRIBUTION					ENGINEERING DATA				MINERALOGY OF THE <2um FRACTION								
			TOT		<2mm															
DEP TOP	DEP BOT	UNIT	GVL %	SD %	ST %	CL %	Cu	W%	LL	PL	PI	EXP %	ILL %	C-K %	CAL	DOL	VERM IND	DI	HSI	INT CPS
24.9		gv-u										11	59	30	40	35	5>	1.3	X	2150
29.5		gv-u										15	54	31	48	30	12>	1.1	X	2060
35.8		gv-u										13	56	31	50	45	5>	1.2	X	2340
39.5		gv-u										15	55	30	40	30	8>	1.2	X	2270
42.7		gv-u										14	57	29	37	36	9>	1.3	X	2100
45.5		gm-z	0	93	4	3	2.0													
55.1		gm-d	20	39	35	26	157.6		21	12	9	9	61	30	35	35	4>	1.4	X	2650
59.9		gm-d										9	63	28	33	30	1>	1.5	X	2820
62.5		gm-d	19	38	35	27	131.6		20	12	8	9	62	29	40	35	2>	1.4	X	2510
70.6		gm-d										12	63	25	45	45	3>	1.7	X	1670
71.2		gm-d	20	38	37	25	165.9		20	12	8	13	63	24	30	30	3>	1.7	X	1765
74.7		gm-d	8	39	38	23	83.4		21	12	9	13	58	29	52	33	3>	1.4	X	2380
77.6		gs-s										30	40	30	22	10	14>	1.3	0	1580
80.8		gs-s										25	50	25	30	30	18>	1.3	0	2830
84.4		gs	13	32	44	24	72.9		22	12	10	26	51	23	30	20	17>	1.4	1	2900
89.7		gs-s										29	49	22	43	35	22>	1.5	0	2950
95.1		gs-s										33	42	25	22	20	28>	1.1	1	2315
99.7		gs-s										36	40	24	30	20	25>	1.1	2	2820
105.1		gs-s										34	43	23	20	20	27>	1.3	1	2030
110.3		gs-s										32	42	26	15	20	25>	1.1	0	2160
115.1		gs-s										26	42	32	10	10	30>	0.9	X	1760
119.9		gs-s										35	35	30	20	10	31>	0.8	X	1990
124.9		gs-s										32	39	29	20	10	30>	0.9	X	2180
129.6		ms-s	0	2	25	73	2.7		50	18	32	27	51	22	25	20	22>	1.7	0	1495

BOREHOLE # F-1
ELEVATION: 614.1

SAMPLE IDENTIFICATION			PARTICLE SIZE DISTRIBUTION					ENGINEERING DATA				MINERALOGY OF THE <2um FRACTION								
			TOT		<2mm															
DEP TOP	DEP BOT	UNIT	GVL %	SD %	ST %	CL %	Cu	W%	LL	PL	PI	EXP %	ILL %	C-K %	CAL	DOL	VERM IND	DI	HSI	INT CPS
10.5		gv-u	5	36	26	38	53.8		44	13	31									
20.0		gv-u	5	40	32	28	84.2		21	11	10									
29.6		gv-u	4	48	29	23	159.7													
34.5		gv-z	5	66	29	5	10.1													
39.0		gv-u	16	43	33	24	207.3					15	51	34	63	35	10>	1.0	X	2890
59.0		gv-u										12	55	33	58	43	8>	1.1	X	2650
60.3		gv-u	7	39	36	25	98.5		25	12	13									
69.0		gv-u	11	39	38	23	123.6					12	60	28	40	53	3>	1.4	X	2810
79.3		gv-u	0	52	28	20	55.0													
98.9		gm-z	37	81	13	6	35.5													
109.0		gs	2	29	40	31	41.6					14	55	31	40	23	7>	1.2	X	2470
109.6		gs										12	54	34	55	23	8>	1.1	X	3150
129.9		gs	0	35	37	28	42.4					12	56	32	45	33	6>	1.1	X	2430
134.8		gs										9	57	34	57	20	7>	1.1	X	2430
139.8		gs										14	51	35	45	35	11>	1.0	X	2310
144.8		gs	20	29	46	45	88.3		27	13	14	11	56	33	52	40	7>	1.1	X	2370
149.8		gs										12	53	35	42	33	8>	1.0	X	2150
154.8		gs										11	54	35	30	20	11>	1.0	X	2180
159.8		gs	8	26	36	38	25.8		28	13	15	12	54	34	30	20	15>	1.0	X	2510
164.8		ms-d										30	25	45	38	23	33>	0.4	X	2630
169.8		ms-d	18	6	43	51	16.4		38	16	22	28	28	44	20	20	28>	0.4	0	2430
171.5		ms-s										10	40	50	0	0	12>	0.8	X	1695
174.6		ms-d										14	50	36	0	0	12>	0.9	X	1440
174.9		ms-s										8	53	39	0	0	9>	0.9	X	1860

BOREHOLE # G-1
ELEVATION: 603.9

SAMPLE IDENTIFICATION			PARTICLE SIZE DISTRIBUTION					ENGINEERING DATA				MINERALOGY OF THE <2um FRACTION								
			TOT		<2mm															
DEP TOP	DEP BOT	UNIT	GVL %	SD %	ST %	CL %	Cu	W%	LL	PL	PI	EXP %	ILL %	C-K %	CAL	DOL	VERM IND	DI	HSI	INT CPS
4.9		fill										51	34	15	0	0	28>	1.5	0	1600
6.7		b										11	68	21	0	0	4>	2.2	X	2290
7.3		b										14	71	15	33	28	4>	3.1	0	1980
20.1		gv-mo										14	69	17	58	47	2>	2.7	X	1750
30.1		gv-u										11	60	29	45	25	2>	1.4	X	2200
40.1		gv-u										10	58	32	63	45	5>	1.2	X	1650
50.5		gv-u	13	38	39	23	102.5		21	13	8	14	56	30	51	35	6>	1.2	X	2390
59.6		gv-m										44	33	22	30	20	31>	1.0	6	2520
63.9		gv-u	16	43	31	26	144.1		22	13	9	12	60	28	50	32	2>	1.4	X	2250
70.3		gv-u	9	43	33	24	110.0		20	12	8	16	54	30	62	30	9>	1.2	0	1910
71.5		gv-u										17	53	30	57	22	11>	1.2	X	2250
72.6		gv-u										20	53	27	57	20	9>	1.3	0	2040
75.1		gv-u	21	42	37	21	159.6		21	13	8	14	56	30	35	30	8>	1.3	X	1465
80.1		gs	17	30	35	35	77.8		27	13	14	15	55	30	35	18	9>	1.2	X	2360
85.0		gs	8	27	35	38	35.8		27	13	14									
90.3		gs	17	29	36	35	67.9		27	13	14	10	53	37	58	35	8>	1.0	X	2270
100.1		gs	12	30	36	34	51.8		27	14	13	11	53	36	32	27	11>	1.0	X	2370
110.1		gs-s	13	25	51	24	30.6		29	15	14	8	55	37	28	20	10>	1.0	X	1820
120.1		gs-s										12	49	39	30	25	12>	0.8	X	2005
130.1		gs-s										25	41	34	15	10	17>	0.8	X	880
133.0		Plm-x	14	66	22	12	88.2		34	24	10	19	55	26	10	10	11>	1.4	1	770

BOREHOLE # H-1
ELEVATION: 560.3

SAMPLE IDENTIFICATION			PARTICLE SIZE DISTRIBUTION					ENGINEERING DATA				MINERALOGY OF THE <2um FRACTION								
			TOT		<2mm															
DEP TOP	DEP BOT	UNIT	GVL %	SD %	ST %	CL %	Cu	W%	LL	PL	PI	EXP %	ILL %	C-K %	CAL	DOL	VERM IND	DI	HSI	INT CPS
25.3		gv-u										12	56	32	52	30	5>	1.2	X	2500
30.1		gv-u	14	40	36	24	122.1		20	12	8	13	56	31	40	38	2>	1.2	X	2260
40.1		gm-d										8	63	29	38	30	1<	1.5	X	2445
45.1		gm-d	14	51	29	20	146.4		18	12	6	7	63	30	35	22	1<	1.4	X	2510
59.7		gm-z	1	97	1	2	3.1													

Location of Borings

Boring	Map	Range	Township	Section	ft from	ft from
A-1	Casey	10N	13W	7	1600 SL	1620 EL
B-1	Casey	10N	13W	7	1970 NL	2220 EL
C-1	Casey	10N	13W	7	1900 SL	1350 WL
D-1	Casey	10N	13W	6	1280 SL	1420 EL
E-1	Casey	10N	13W	6	1270 SL	700 WL
F-1	Casey	10N	13W	5	880 NL	300 WL
G-1	Casey	10N	13W	5	1200 NL	2500 WL
H-1	Casey	10N	13W	18	500 NL	1880 WL

Table 1. Mean values of particle-size determinations, semiquantitative mineralogical analyses, and selected physical characteristics from subsamples of cores A-1 to H-1 (Battelle Memorial Institute and Hanson Engineers, 1990c)

Unit	Particle Size Distribution (mm) Total Gravel(%) >2	<2 Sand (%) 2.0-0.63	Silt (%) 0.004-0.63	Clay (%) <0.004	Moisture content W%	Coeffient of uniformity Cu	Atterberg Limits Liquid Limit	Plastic Limit	Plasticity Index
Cahokia Alluvium (c)	9.4±17.5 0-60(10)	63.6±38.6 2-96(10)	19.2±19.5 2-5310)	17.2±19.5 2-52(10)	20.5±5.9 8.8-29.1(10)	15.4±14.6 2-4610)	46.0±4.1 41-51(3)	16.6±3.8 14-22(3)	29.3±5.6 24-37(3)
Glasford Formation									
Vandalia Till Member									
melange facies (gv-m)	14.8±6.3 2-22(10)	37.9±6.2 23-44(10)	35.9±5.0 29-46(10)	26.2±5.5 18-40(10)	11.2±3.2 7.2-19.0(9)	126.9±55.8 18.2-191.3(10)	23.3±6.2 19-41(10)	11.9±1.1 10-14(10)	11.4±5.9 8-28(10)
uniform diamicton facies (gv-u)	12.8±6.0 0-25(38)	41.7±4.9 33-52(38)	34.7±4.6 26-44(38)	23.5±3.4 18-38(38)	10.1±0.9 6.9-12.1(22)	124.3±41.3 39-229(38)	21.8±4.2 18-44(32)	12.2±1.2 10-18(32)	9.7±4.1 6-31(32)
Mulberry Grove Member									
sand and gravel facies (gm-z)	20.0±20.6 0-77(16)	89.0±8.9 63-97(16)	7.3±6.7 1-26(16)	3.7±2.5 1-11(16)	14.1±4.0 7.3-21.7(16)	16.1±17.5 2.4-52.6(16)	—	—	—
diamicton facies (gm-d)	13.8±7.4 6-27(6)	44.5±11.2 32-62(6)	37.8±7.6 24-46(6)	17.6±4.5 11-24(6)	13.8±2.4 10.4-18.4(6)	88.8±33.5 49.6-135.6(6)	19.5±2.1 16-21(4)	12.7±0.4 12-13(4)	6.8±2.2 3-8(4)
Smithboro Till Member									
loam diamicton facies (gs)	9.5±4.4 0-20(29)	29.4±2.4 26-36(29)	39.3±4.3 35-50(29)	31.8±5.5 18-45(29)	13.7±1.5 10.8-17.8(20)	46.6±17.0 2.3-88.3(29)	26.2±2.8 18-33(25)	13.0±0.6 12-14(25)	13.2±3.0 4-20(25)
silt loam diamicton facies (gs-s)	4.3±3.1 1-13(15)	20.1±3.8 9-25(15)	50.7±8.5 41-69(15)	29.1±6.7 12-38(15)	16.8±3.0 10.1-21.1(14)	24.2±7.6 16.7-44.5(15)	29.8±2.0 26-35(13)	14.6±0.9 13-16(13)	15.0±2.2 13-22(13)
Martinsville Sand									
sand and gravel facies (ms-z)	22.5±24.6 0-73(11)	82.2±7.1 71-91(11)	12.6±6.3 5-26(11)	5.1±3.0 0-11(11)	16.2±4.7 6.9-24.1(11)	21.3±31.5 4.4-118.1(11)	—	—	—

Mineralogy of the <2 μm fraction

Expandable Clay Minerals %	Illite %	Chlorite & Kaolinite %	Calcite (CPS)	Dolomite (CPS)	Diffraction Intensity Ratio	Heterogeneous Swelling Index
42.6±5.2	33.6±2.4	23.6±4.5	-0-	-0-	1.0±0.2	2.3±1.2
39-50(3)	32-37(3)	18-29(3)	0-0(3)	0-0(3)	0.7-1.2(3)	1-4(3)
18.2±10.9	51.5±10.6	31.1±3.3	45.6±20.7	34.9±12.6	1.2±0.2	0.6±1.6
9-44(14)	26-63(14)	22-35(14)	0-77(14)	0-53(14)	0.5-1.5(14)	0-6(14)
11.3±2.9	58.6±3.5	30.0±2.3	46.5±11.1	36.2±9.2	1.3±0.2	-0-
7-20(51)	51-66(51)	24-35(51)	30-75(51)	20-66(51)	1.0-1.8(51)	0-0(51)
—	—	—	—	—	—	—
13.2±7.9	58.2±6.3	28.5±6.8	43.8±9.6	28.8±5.7	1.4±0.1	-0-
4-23(4)	51-65(4)	26-31(4)	35-60(4)	20-36(4)	1.3-1.4(4)	0-0(4)
15.1±6.8	51.6±4.5	33.1±4.8	41.9±9.4	27.1±6.0	1.1±0.1	0.2±0.7
7-36(26)	39-57(35)	23-45(35)	17-58(35)	18-40(35)	0.6-1.4(35)	0-3(35)
24.6±10.0	43.5±5.7	32.1±7.2	28.4±9.1	22.0±8.0	1.0±0.3	0.4±0.7
8-37(26)	34-55(26)	22-47(26)	10-50(26)	10-37(26)	0.6-1.5(26)	0-2(26)
—	—	—	—	—	—	—

Table 2 Comparison of lithostratigraphy and stratigraphic nomenclature used in this report and Battelle Memorial Institute and Hanson Engineers (1990a)

Battelle 1990a	This report
Cahokia Alluvium	Cahokia Alluvium
Peyton Colluvium	Peyton Colluvium
Parkland Sand	Parkland Sand
Peoria Loess	Peoria Loess
not reported/not present at MAS	Wedron Formation
Roxana Silt	sandy silt facies of the Roxana Silt
Berry Clay	Berry Formation
Upper Sand	Pearl Formation
Glasford Formation	Glasford Formation
Vandalia Till Member	Vandalia Till Member
Fractured Vandalia Till	mèlange facies
Vandalia Till Vandalia Sand	uniform diamicton facies
	Mulberry Grove Member
Sand Facies	silt facies, sand and gravel facies, diamicton facies
	Smithboro Till Member
Smithboro Till	loam diamicton facies and silt diamicton facies
Petersburg Silt	Petersburg Silt
	Martinsville sand
Basal Sand	sand and gravel facies
Pre-Illinoian Silt and Clay	silty clay facies diamicton facies Banner Formation Lierle Clay Member
not reported/not present at MAS	Casey till member